# OFFSHORE OIL:
## ITS IMPACT ON TEXAS COMMUNITIES

### Volume III Aggregate State Impacts And
### Volume IV Appendices

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VOLUME III
AGGREGATE STATE IMPACTS

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## VOLUME III: AGGREGATE STATE IMPACTS

## ACCOMPANYING VOLUMES

# 1. INTRODUCTION AND SUMMARY

## Scope of Analysis

As other parts of this study have noted, there are several economic sectors which may not be impacted by any given OCS scenario in isolation (because scenarios encompass only one defined geographical area and include as a basis for analysis only the activities expected to take place in that area) but may feel impacts when the aggregation of all potential oil and gas activities in the Texas Federal OCS is considered. Among such sectors are petroleum refining, gas processing, mobile rig construction, platform construction, and petrochemical processing. Each of these sectors is analyzed in this Volume.

The analysis of each of these sectors was directed primarily toward determining if oil and/or gas production from the Texas Federal OCS was likely to necessitate an enlargement of that sector in Texas, either in the form of expansion of existing facilities or construction of new ones. To the extent that enlargements were found to be likely, the impacts of such development were assessed.

No attempt has been made to quantify the aggregated fiscal benefit or deficit for the entire State of Texas due to all potential OCS oil and gas activity. To make such an attempt would be, at best, hazardous, given the uncertainty surrounding the level of future OCS development. Furthermore, results of such an analysis are likely to be tentative and potentially misleading. The state fiscal effects of lease sales which have recently taken place or for future sales for which tract nominations have been announced, can be calculated, and such calculations are included in the scenario analyses.

## Results

The analysis of petroleum refining activities in Texas results in the conclusion that production from the Texas Federal OCS, in and of itself, is extremely unlikely to necessitate any expansion of the refining sector in Texas. It is important to remember that demand for refining capacity is considered to be more a function of demand for finished products than of supply of crude oil. It is also likely that future oil production from the Texas Federal OCS will be substitutes for - not additions to - the 1.4 million barrels of foreign crude oil which were input to Texas refineries on a daily basis in September, 1976.

When the overall energy supply picture is analyzed (rather than oil production from the Texas Federal OCS only), refining capacity expansion in Texas by 1985 could range from none to 1.7 million barrels per day, depending on the set of variables selected. Accordingly, the impacts of expansion, in terms of income and State and local tax payments, vary widely. Chapter 2 contains a thorough analysis of future expansions of the refining sector in Texas.

Chapter 3 compares estimates of additional Texas Federal OCS gas production through 1985 with existing capacity and throughput of gas processing plants in the Texas coastal region. The results reveal that if an 80% utilization rate for gas plants is assumed, the anticipated increase in OCS gas production by 1985 would require only 10% of the current excess capacity in the region. The projected future production of OCS gas, then, can reasonably be expected to reverse the current downward trend in capacity utilization but not to require, in and of itself, significant new capacity.

In Chapter 4, the impact of oil and gas activities in the Texas Federal OCS on the exploratory drilling rig construction sector is analyzed. The analysis suggests that while a surplus of mobile rigs appears to be the current case, demand will balance supply in the latter part of 1979. Moreover, it appears that if expansion were to be required in yard capacity, such expansion would probably not take place until the 1980's. Finally, it seems unlikely that Texas Federal OCS development, in and of itself, would warrant such capacity expansions.

The impact of oil and gas development in the Texas Federal OCS on the platform fabrication sector is analyzed in Chapter 5. In sum, the analysis concludes that since demand for fixed platforms is a derived demand based on such variables as rate of leasing, private investment, decisions, and cost/price dynamics; any of dozens of future public or private policy decisions could seriously alter the present platform supply/demand picture. All other things being equal, however, demand for platforms is likely to increase slightly in the near future leading most probably to minor capacity increases primarily in the form of expansions of existing facilities. Further, such expansions in existing facilities are most likely to take place in Louisiana, rather than in Texas.

Chapter 6 analyzes the impact of OCS oil and gas development on petrochemical plants. The analysis points out that petrochemical plants ultimately depend on refineries and gas plants for feedstocks. Thus, since it was concluded that oil and gas activity in the Texas Federal OCS is not likely to generate capacity expansions of refining or gas processing in Texas, Chapter 6 concludes that expansion of the petrochemical sector - due to Texas Federal OCS activity - is equally unlikely.

In Chapter 7, the impact of OCS oil and gas production on storage facilities is examined. Although existing, relevant data is very sketchy, the analysis concludes that storage facilities construction or expansion are unlikely to be undertaken simply due to Texas OCS production.

## 2. IMPACT OF CAPACITY INCREASES IN TEXAS REFINING INDUSTRY

Petroleum refining is an extremely important industry in Texas, with over 26 percent of the total U.S. refining capacity located within the State. Consequently, any analysis of the impacts of OCS oil and gas development on the State would be incomplete without an investigation into its effect on the petroleum refining sector.

The demand for refining capacity is derived from the demand for petroleum products, rather than from the supply of crude oil. Thus, refining capacity is not automatically expanded to handle newly discovered OCS crude oil. The construction of a new refinery is more likely if there is no refining capacity reasonably close to the find, if the find is large, and/or if the adjacent region is a large demand center for refined products. If, however, the new crude could be refined with existing capacity, traded with another oil company (assuming each has crude near the other's excess capacity), or substituted for imported crude oil, it is very unlikely that a new refinery would be built or an existing one expanded.

When these factors are considered, it becomes unlikely that refining capacity will be expanded in the State solely to accommodate new OCS crude oil. Crude capacity in Texas refineries was approximately 4 million barrels per calendar day (B/CD) as of January 1, 1976 (Bureau of Mines, Petroleum Refineries in the U.S. and Puerto Rico) while total Texas production (including that from offshore wells) during 1975 and through October, 1976 averaged 3.2 million B/CD. Offshore production in the first ten months of 1976 averaged 3,200 B/CD, or only 0.8 percent of the difference between Texas crude production and refinery runs at 90 percent utilization of refining capacity. Put another way, offshore crude production would have to increase by 12,400 percent to replace all of the non-Texas crude inputs to Texas refineries, given current onshore production and 90 percent utilization of capacity. This is most improbable. Instead, it is more reasonable to conclude that new OCS oil will merely replace foreign crude oil inputs into Texas refineries, which entered State refineries at a rate of over 1.4 million B/CD in September, 1976.

Even though an increase in capacity due to OCS oil development is unlikely, the economic impact on the State of possible expansion through 1985 under different sets of assumptions is considered below in terms of income and State and local tax payments. The analysis examines the industry in general and provides one method for assessing the impact of industrial expansion upon the State. The expansion, however, is not assumed to be caused by OCS oil development.

## Projected New Capacity

As mentioned above, the demand for refining capacity depends on the demand for refined products. Because of this, the process of estimating needed new capacity becomes, first, one of determining the level of refined product demand which will be unmet by existing capacity. This was done for the nation for the years 1980 and 1985 in Figure 1 and involved the following steps:

1. Estimating total demand for refined products, which is the sum of domestic demand and exports. Two forecasts were used to derive a probable range of future domestic demand. The first is the FEA Reference Case (FEA, National Energy Outlook, March, 1976); the second is provided by the Bureau of Mines (U.S. Energy Through the Year 2000 (Revised), December, 1975). Exports are assumed to remain at the current level.

2. Subtracting from the total demand that portion which will be supplied by natural gas processing plants. The current level of output net of the amount used by refineries for blending purposes (and therefore not included in final demand) is assumed. The result is the demand to be met by refinery output.

3. Subtracting existing and planned capacity from the results in step two gives that product demand that will be unmet by U.S. refining capacity in 1980 and 1985. Planned capacity consists of new refineries, expansions, and reactivations scheduled in the United States through 1980. It does not include those projects which are uncertain or are in the early stages of planning.

A glance at Figure 1 shows that estimates of unmet demand vary depending upon which forecast of domestic demand is used. Many such forecasts exist; the FEA estimates tend to be low, while the BOM projections assume a higher growth rate in final demand.

Additional refining capacity was then estimated for the nation as a whole and for Texas under three sets of assumptions. In the first case, it is assumed that the U.S. is self-sufficient in refined products. In the second, the U.S. imports products at the current level of 1.9 MMB/D. Finally, the U.S. is assumed to import products at the current level from all areas except the Caribbean. From there it would import sufficient products to utilize most of that area's exportable capacity. The results are shown in Figure 2.

Inspection of Figure 2 reveals a wide range of required expansion. Differences exist due to varying levels of final demand and product imports. In 1980, for example, note the extremes of (1) surplus capacity

Figure 1

Estimated Demand For Refined Products Unmet
By Current And Planned U.S. Refining Capacity
1980 and 1985
MMB/CD

| | 1980 | | 1985 | |
|---|---|---|---|---|
| | FEA [1] | Bureau of Mines [2] | FEA [1] | Bureau of Mines [2] |
| Domestic demand for refined products | 17.7 | 20.4 | 20.7 | 22.6 |
| Exports [3] | 0.2 | 0.2 | 0.2 | 0.2 |
| Total demand | 17.9 | 20.6 | 20.9 | 22.8 |
| Less: natural gas liquids (NGL) supplied by natural gas plants [4] | 0.9 | 0.9 | 0.9 | 0.9 |
| Demand to be met by refinery output | 17.0 | 19.7 | 20.0 | 21.9 |
| Less refinery crude runs given existing capacity and planned increases through 1980 [5] | 16.1 | 16.1 | 16.1 | 16.1 |
| Refined product demand unmet given planned refining capacity and current gas processing plant output | 0.9 | 3.6 | 3.9 | 5.8 |

1. FEA Reference Case, National Energy Outlook (Washington, D.C.: GPO, 1976), p. G-3, G-23. Assumes business-as-usual supply and demand cases and imported oil priced at $13 per barrel.

2. Bureau of Mines, United States Energy Through the Year 2000 (Revised), U.S. Department of Interior, December, 1975, p. 29.

3. Assumes that U.S. petroleum exports will remain at current levels, which averaged 0.2 MMB/D for 1976. See Monthly Energy Review, FEA, November, 1976.

4. Assumes that current levels of natural gas liquids produced at gas processing plants net of that utilized by refineries for blending purposes will continue.

5. FEA, Trends in Refinery Capacity and Utilization, June, 1976, p. 8. Includes new refineries, expansions, and reactivations scheduled in the U.S. through 1980. Does not include those projects which are uncertain or are in the early stages of planning. Assumes 90 percent utilization of capacity.

Figure 2

Additional U.S. And Texas Refining
Capacity Needed
1980 and 1985
MMB/CD

| | 1980 | | 1985 | |
|---|---|---|---|---|
| U.S. | FEA [1] | Bureau of Mines [2] | FEA [1] | Bureau of Mines [2] |
| Case I: No Imports | | | | |
| Added Crude Runs | 0.9 | 3.6 | 3.9 | 5.8 |
| Added Capacity[3] | 1.0 | 4.0 | 4.3 | 6.4 |
| Case II: Current Level of Of Product Imports[4] | | | | |
| Added Crude Runs | (1.0)[5] | 1.7 | 2.0 | 3.9 |
| Added Capacity[3] | (1.1) | 1.9 | 2.2 | 4.3 |
| Case III: Full Utilization of Carribbean Capacity[6] | | | | |
| Added Crude Runs | (1.9) | 0.8 | 1.1 | 3.0 |
| Added Capacity[3] | (2.1) | 0.9 | 1.2 | 3.3 |
| Texas[7] | | | | |
| Case I: No Imports | | | | |
| Added Crude Runs | .2 | 0.9 | 1.0 | 1.5 |
| Added Capacity[3] | .3 | 1.0 | 1.1 | 1.7 |
| Case II: Current Level of Product Imports[4] | | | | |
| Added Crude Runs | ( .3) | 0.4 | 0.5 | 1.0 |
| Added Capacity[3] | ( .3) | 0.4 | 0.6 | 1.1 |
| Case III: Full Utilization of Carribbean Capacity[6] | | | | |
| Added Crude Runs | ( .5) | 0.2 | 0.3 | 0.8 |
| Added Capacity[3] | ( .6) | 0.2 | 0.3 | 0.9 |

1. FEA Reference Case, National Energy Outlook (Washington, D.C.: GPO, 1976), p. G-3, G-23. Assumes business-as-usual supply and demand cases and imported oil priced at $13 per barrel.
2. Bureau of Mines, United States Energy Through the Year 2000 (Revised), U.S. Department of Interior, December, 1975.
3. Assumes 90 percent utilization.
4. Assumes product imports will remain at 1976 average level of 1.9 MMB/D.
5. Parentheses ( ) indicate surplus.
6. Assumes that the percentage of Caribbean product exported to the U.S. will be approximately 80% of that area's total exports (C I A, Intelligence Handbook: Export Refining Centers of the World, June, 1975). Total net exportable capacity is obtained from FEA, Trends in Refinery Capacity and Utilization, June, 1976, p. 32.
7. Assumes the current ratio of Texas capacity to total U.S. capacity (26 percent) will continue.

of 2.1 MMB/CD if case III and the FEA estimates of final demand are assumed, and (2) needed expansion of 4 MMB/CD (about one-fourth of existing capacity) given no product imports and the BOM forecast. The extremes of needed capacity in 1985 are 1.2 MMB/CD and 6.4 MMB/CD.

Other projections of additional capacity required by 1980 also exhibit a wide range. Estimates given in Senate hearings on oil refining capacity in August, 1973 ranged from 1.9 to 8.0 MMB/D and averaged 4.5 MMB/D. These tend to be higher than the projections in Figure 2 since they are based on pre-embargo demand figures and lower estimates of existing capacity. One study of capacity assuming no product imports estimated total required capacity to be about 18 MMB/D in 1980 and 21 MMB/D in 1985 (Murray, Mobile Oil, 1974). This would imply needed added capacity equal to about 2 MMB/D in 1980 and 5 MMB/D in 1985, given about 16 MMB/D in existing capacity.

Twenty-six percent of the U.S. refining capacity is located in Texas. This proportion was applied to the national estimates in order to project additions to Texas capacity, under the assumption that the current relationship of Texas capacity to total capacity will continue.

Of the three cases examined, the last seems most likely because the bulk of the refineries in the Caribbean are owned and operated by U.S. corporations and were built to refine products primarily for export to the U.S. By 1980, the FEA estimates that the area's net exportable capacity will be equal to 3.1 MMB/CD. If it is assumed that about 80 percent of the product exports will continue to go to the U.S., full utilization of the area's capacity would permit the export to the U.S. of 0.9 MMB/CD in addition to the quantity currently exported. It seems reasonable that, all other things, being equal, existing capacity would be utilized before new capacity is built. Given the BOM estimate of final demand, this would require 3.3 MMB/CD in additional capacity nationally, and 0.9 MMB/CD in Texas, by 1985.

Projects which are uncertain or are in the early stages of planning are not included in Figures 1 and 2. The total capacity of such projects is 3.2 MMB/CD, or slightly less than the maximum required in case III. Significantly, 76 percent of that is scheduled for the East Coast, and none is planned in Texas. If these projects come to fruition, very little expansion of the refining industry is seen in Texas through 1985. It should be noted, however, that continued opposition to refinery construction on the East Coast due to environmental concerns may prevent the realization of many of these projects. Such obstruction of construction would support the assumption that new capacity will be distributed among regions as in the past.

In short, depending upon the case selected, refining capacity expansion in Texas by 1985 could range from none to 1.7 MMB/CD. The former would occur if the Caribbean capacity were fully utilized and if those projects which are in the early stages of planning or are uncertain are ultimately undertaken. The latter assumes no product imports, and the higher final demand estimates.

## Impact of Refinery Expansion on the Texas Economy

The effects of added refining capacity on income and on State and local tax payments were estimated by applying the appropriate multipliers (summarized in Figure 3) from the Texas Input/Output (I/O) Model. The coefficients were then multiplied by the value of increased output per year for each case and each estimate of refined product demand. The results are shown in Figure 4 (FEA forecast) and 5 (BOM forecast) for the years 1980 through 1985.

Figure 3

Coefficients From the Texas I/O Model
Petroleum Refining Sector
(Dollars per dollar of output per year)

| | |
|---|---|
| Income (Direct & Indirect) | 0.5494900703 |
| State Tax Payment | |
| Direct | 0.00275821 |
| Indirect | 0.0334949 |
| Local Tax Payment | |
| Direct | 0.00171558 |
| Indirect | 0.0173928 |

A determination of the value of increased output per year is central to any use of the above I/O multipliers. This required that the following assumptions be made:

1. The volume of refined product outputs is equal to the volume of crude runs. Processing gains, which are small, are ignored.

2. Since it takes from three to five years to construct a new refinery or undertake a major expansion, all the capacity projected by 1980 will become available in that year. The added capacity by 1985 will be phased-in in equal increments in the years between 1980 and 1985.

3. The value of output is the volume multiplied by an assumed price of $14.40 per barrel. This is the weighted average price of refined products assumed in the FEA 1985 Reference case. The use of a higher or lower price would increase or decrease estimates accordingly.

Figure 4

Economic Impact of Refinery Expansion in Texas
FEA Estimate of Final Demand
1980-1985
($1975)

| | 1980[1] | 1981[1] | 1982[1] | 1983[1] | 1984[1] | 1985[1] | Total |
|---|---|---|---|---|---|---|---|
| Case I: No Imports | | | | | | | |
| Increased Output (MB/CD) | 200 | 360 | 520 | 680 | 840 | 1,000 | 3,600 |
| Value of Output[2] | $2,880,000 | $5,184,000 | $7,488,000 | $9,792,000 | $12,096,000 | $14,400,000 | $51,840,000 |
| Increase in: | | | | | | | |
| Income | 1,582,531 | 2,848,557 | 4,114,582 | 5,380,607 | 6,646,632 | 7,912,657 | 28,485,566 |
| State Tax Payments | 104,409 | 187,937 | 271,463 | 354,990 | 438,517 | 522,045 | 1,879,361 |
| Direct | 7,944 | 14,299 | 20,653 | 27,008 | 33,363 | 39,718 | 142,985 |
| Indirect | 96,465 | 173,638 | 250,810 | 327,982 | 405,154 | 482,327 | 1,736,376 |
| Local Tax Payments | 35,870 | 64,566 | 93,262 | 121,958 | 150,654 | 179,350 | 645,660 |
| Direct | 4,941 | 8,894 | 12,846 | 16,799 | 20,752 | 24,704 | 88,936 |
| Indirect | 30,929 | 55,672 | 80,416 | 105,159 | 129,902 | 154,646 | 556,724 |
| Case II: Current Level of Product Imports | | | | | | | |
| Increased Output (MB/CD) | - | 100 | 200 | 300 | 400 | 500 | 1,500 |
| Value of Output[2] | - | $1,440,000 | $2,880,000 | $4,320,000 | $ 5,760,000 | $ 7,200,000 | $21,600,000 |
| Increase in: | | | | | | | |
| Income | - | 791,266 | 1,582,531 | 2,373,797 | 3,165,063 | 3,956,329 | 11,868,986 |
| State Tax Payments | - | 52,205 | 104,409 | 156,613 | 208,818 | 261,022 | 783,067 |
| Direct | - | 3,972 | 7,944 | 11,915 | 15,887 | 19,859 | 59,577 |
| Indirect | - | 48,233 | 96,465 | 144,698 | 192,931 | 241,163 | 723,490 |
| Local Tax Payments | - | 17,935 | 35,870 | 53,805 | 71,740 | 89,675 | 269,025 |
| Direct | - | 2,470 | 4,941 | 7,411 | 9,882 | 12,352 | 37,056 |
| Indirect | - | 15,465 | 30,929 | 46,394 | 61,858 | 77,323 | 231,969 |
| Case III: Full Utilization Of Caribbean Capacity | | | | | | | |
| Increased Output (MB/CD)[2] | - | 60 | 120 | 180 | 240 | 300 | 900 |
| Value of Output[2] | - | $ 864,000 | $1,728,000 | $2,592,000 | $ 3,456,000 | $ 4,320,000 | $12,960,000 |
| Increase in: | | | | | | | |
| Income | - | 474,759 | 949,519 | 1,424,278 | 1,899,038 | 2,373,797 | 7,121,391 |
| State Tax Payments | - | 31,323 | 62,645 | 93,968 | 125,290 | 156,613 | 469,839 |
| Direct | - | 2,383 | 4,766 | 7,149 | 9,532 | 11,915 | 35,745 |
| Indirect | - | 28,940 | 57,879 | 86,819 | 115,758 | 144,698 | 434,094 |
| Local Tax Payments | - | 10,761 | 21,522 | 32,283 | 43,044 | 53,805 | 161,415 |
| Direct | - | 1,482 | 2,965 | 4,447 | 5,929 | 7,411 | 22,234 |
| Indirect | - | 9,279 | 18,557 | 27,836 | 37,115 | 46,394 | 139,181 |

1. All capacity projected for 1980 will be available in that year, since it takes 3 to 5 years to complete a major expansion or new refinery. The capacity increase from 1980 to 1985 will be phased-in in equal annual increments.

2. Average weighted price of refined products is assumed to be $14.40 per barrel (FEA price for 1985 Reference case, $1975).

Figure 5

Economic Impact of Refinery Expansion in Texas
BOM Estimate of Final Demand
1980-1985
($1975)

| | 1980[1] | 1981[1] | 1982 | 1983[1] | 1984[1] | 1985[1] | Total |
|---|---|---|---|---|---|---|---|
| Case I: No Imports | | | | | | | |
| Increased Output (MB/CD) | 900 | 1,020 | 1,140 | 1,260 | 1,380 | 1,500 | 7,200 |
| Value of Output[2] | $12,960,000 | $14,688,000 | $16,416,000 | $18,144,000 | $19,872,000 | $21,600,000 | $103,680,000 |
| Increase in: | | | | | | | |
| Income | 7,121,391 | 8,070,910 | 9,020,429 | 9,969,948 | 10,919,467 | 11,868,986 | 56,971,131 |
| State Tax Payments | 469,840 | 532,486 | 595,131 | 657,776 | 720,422 | 783,067 | 3,758,722 |
| Direct | 35,746 | 40,513 | 45,279 | 50,045 | 54,811 | 59,577 | 285,971 |
| Indirect | 434,094 | 491,973 | 549,852 | 607,731 | 665,611 | 723,490 | 3,472,751 |
| Local Tax Payments | 161,415 | 182,937 | 204,459 | 225,980 | 247,503 | 269,025 | 1,291,319 |
| Direct | 22,234 | 25,198 | 28,163 | 31,127 | 34,092 | 37,057 | 177,871 |
| Indirect | 139,181 | 157,739 | 176,296 | 194,853 | 213,411 | 231,968 | 1,113,448 |
| Case II: Current Level of Product Imports | | | | | | | |
| Increased Output (MB/CD) | 400 | 520 | 640 | 760 | 880 | 1,000 | 4,200 |
| Value of Output[2] | $ 5,760,000 | $ 7,488,000 | $ 9,216,000 | $10,944,000 | $12,672,000 | $14,400,000 | $ 60,480,000 |
| Increase in: | | | | | | | |
| Income | 3,165,063 | 4,114,582 | 5,064,101 | 6,013,619 | 6,963,138 | 7,912,657 | 33,233,160 |
| State Tax Payments | 208,818 | 271,463 | 334,109 | 396,754 | 459,399 | 522,045 | 2,192,588 |
| Direct | 15,887 | 20,653 | 25,420 | 30,186 | 34,952 | 39,718 | 166,816 |
| Indirect | 192,931 | 250,810 | 308,689 | 366,568 | 424,447 | 482,327 | 2,025,772 |
| Local Tax Payments | 71,740 | 93,262 | 114,784 | 136,306 | 157,828 | 179,350 | 753,270 |
| Direct | 9,882 | 12,846 | 15,811 | 18,775 | 21,740 | 24,704 | 103,758 |
| Indirect | 61,858 | 80,416 | 98,973 | 117,531 | 136,088 | 154,646 | 649,512 |
| Case III: Full Utilization Of Caribbean Capacity | | | | | | | |
| Increased Output (MB/CD) | 200 | 340 | 480 | 620 | 760 | 900 | 3,300 |
| Value of Output[2] | $ 2,880,000 | $ 4,896,000 | $ 6,912,000 | $ 8,928,000 | $10,944,000 | $12,960,000 | $ 47,520.000 |
| Increase in: | | | | | | | |
| Income | 1,582,531 | 2,690,303 | 3,798,075 | 4,905,847 | 6,013,619 | 7,121,391 | 26,111,766 |
| State Tax Payments | 104,409 | 177,495 | 250,582 | 323,677 | 396,754 | 469,840 | 1,722,747 |
| Direct | 7,941 | 13,504 | 19,065 | 24,625 | 30,186 | 35,746 | 131,070 |
| Indirect | 96,465 | 163,991 | 231,517 | 299,042 | 366,568 | 434,094 | 1,591,677 |
| Local Tax Payments | 35,870 | 60,979 | 86,088 | 111,197 | 136,306 | 161,415 | 591,855 |
| Direct | 4,941 | 8,399 | 11,858 | 15,317 | 18,775 | 22,234 | 81,524 |
| Indirect | 30,929 | 52,580 | 74,230 | 95,880 | 117,531 | 139,181 | 510,331 |

1. All capacity projected for 1980 will be available in that year, since it takes 3 to 5 years to complete a major expansion or new refinery. The capacity increase from 1980 to 1985 will be phased-in in equal annual increments.

2. Average weighted price of refined products is assumed to be $14.40 per barrel (FEA price for 1985 Reference case, $1975).

As expected, the impacts vary, depending upon the case and demand forecast selected. For example, the total increase in income through 1985 due to the postulated expansion could range from about $7.1 million (case III/FEA forecast) to almost $57 million (case I/BOM forecast). The ranges for State and local tax payments are $470,000 to $3.8 million, and $160,000 to $1.3 million, respectively.

A note of caution should be sounded at this point. The purposes of this study is not to examine the economic impact of expansion in the petroleum refining sector per se. Rather, it is to assess the effects of OCS oil and gas development on the State economy. The latter, of course, required a look at the probable impact of development on the Texas refining industry, and it was concluded that new OCS finds, in and of themselves, should not cause capacity increases. As a result, although a general impact analysis was done, it is less detailed and complete than would be the case if the impacts were seen to be related to OCS development.

A research effort primarily concerned with the refining sector would require a more comprehensive analysis, including, for example, an estimate of costs to State government. Such an analysis should be undertaken with an awareness that certain methodological problems exist, to wit, rather heroic assumptions must be made concerning, first, new employment resulting from expansion, and second, State per capita expenditures.

Determination of total new employment requires that the projected capacity increase be divided between new construction and expansion, and that assumptions be made concerning the average size of each project and number employed. The new employment thus generated must somehow be divided between existing Texas residents and new residents.

Unfortunately, there is no direct relationship between the size of a refinery, and the number employed. Both a large and small refinery can be operated by the same number of operating personnel, although a large one may require more maintenance and office personnel. Perhaps the best way to determine a relationship between capacity and number employed is to divide total employment in the sector by total capacity.

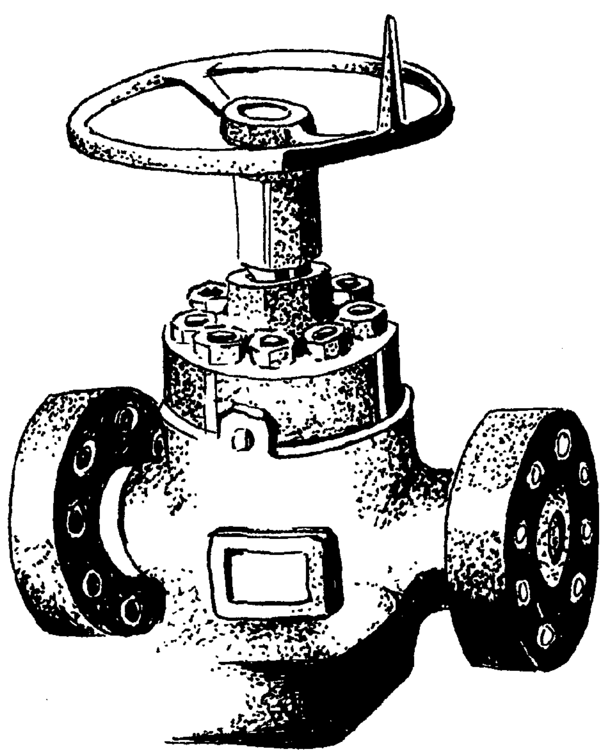
State per capita expenditures would then be multiplied by new population to estimate increased costs. However, State expenditures vary widely among regions. Thus, determination of per capita expenditures would require added assumptions concerning location of capacity increases.

In pursuing this analysis, one must be careful that the addition of these assumptions to those already employed in deriving postulated capacity increases not result in specious impact estimates.

## Summary

Estimates of capacity expansions for the Texas refining industry through 1985 differ greatly because of differing estimates of demand for refining products and assumptions concerning the level of product imports. As a result, the economic impact of these expansion in terms of income and State and local tax payments also varies.

It is unlikely that refineries will be expanded in Texas solely to process new OCS crude oil. Rather, the new crude would most probably replace foreign crude currently being imported into State refineries. Thus, although the economic impact of capacity expansion is analyzed, the effects should not be thought of as caused by OCS development. Other factors such as the degree of environmental opposition to construction on the East Coast, the development of a superport off the Texas coast, and U.S. policies concerning refined product imports will have more of an influence on future investment in Texas refineries.



# 3. EFFECTS OF OCS DEVELOPMENT ON GAS PROCESSING SECTOR

Gas processing plants perform a necessary function in preparing natural gas for final consumption: they remove liquid hydrocarbons, carbon dioxide and hydrogen sulfide from raw gas. The dry gas is then transferred to a gas pipeline and the liquid products are removed from the plants by truck, rail, or pipeline. Gas plants will therefore be found in an adjacent onshore region if commercial quantities of natural gas are discovered in an OCS area. More specifically, they will be located in line with the landfall of the pipeline bringing the raw gas to shore and a commercial pipeline.

The construction of new gas processing facilities is thus a potential effect of OCS gas development. In order to determine whether expanded capacity is a probable effect, estimates of additional OCS gas production through 1985 were compared with existing capacity and throughput of plants in the Texas coastal region.

Total Federal OCS gas production off the Texas coast equalled 101,434,765 MCF in 1975 or about 278 MMCF/D. Estimates of yearly production, assuming a nine percent annual growth rate, are shown in Figure 6. In 1985, for example, total production is postulated to be approximately 658 MMCF/D, representing an increase of 380 MMCF/D, or 137 percent, over the 1975 production level.

This compares with average plant capacity and production in the Texas coastal region in 1975 of 10,300 MMCF/D and 5,760 MMCF/D, respectively. (See Figure 7.) If an eighty percent utilization rate were assumed, the anticipated increase in OCS gas production by 1985 would require only ten percent of the current excess capacity in the region. Consequently, no new capacity should be required to process newly-discovered OCS gas. This analysis, of course, excludes a consideration of new construction needed to replace older existing capacity which may be scrapped.

Almost forty percent of the U.S. gas processing capacity is located in Texas, and almost fifteen percent is in the State's coastal region. All three areas have experienced declining throughput and utilization in recent years due to a combination of factors. First, total gas production has decreased. Second, a growing portion of non-associated gas (that is, gas not contained in oil) is dry, thus not requiring processing. The trends are set forth in Figure 8. The current utilization rate in the coastal region (56 percent), in fact, is lower than that of Texas as a whole (63 percent), and of the nation (67 percent).

In short, it is anticipated that the increased OCS gas production will be in quantities large enough to reverse the downward trend in capacity utilization but not so large as to require significant new capacity.

Figure 6

Federal Texas OCS Gas Production
1975-1985

| | Gas Production | | Increased Production |
|---|---|---|---|
| | MMCF | MMCF/D | Over 1975 (MMCF/D) |
| 1975 [1] | 101,435 | 278 | - |
| 1976 [2] | 110,564 | 303 | 25 |
| 1977 | 120,515 | 330 | 52 |
| 1978 | 131,361 | 360 | 82 |
| 1979 | 143,183 | 392 | 114 |
| 1980 | 156,070 | 428 | 150 |
| 1981 | 170,116 | 466 | 188 |
| 1982 | 185,427 | 508 | 230 |
| 1983 | 202,115 | 554 | 276 |
| 1984 | 220,305 | 604 | 326 |
| 1985 | 240,133 | 658 | 380 |

1. Actual production figure taken from Texas Railroad Commission Offshore Production Files.

2. Data from 1976 on were projected from the 1975 figure, assuming a nine percent annual growth rate as stated in Product 1A1.1.

Figure 7

Average Capacities And Production, Gas Processing Plants In The Texas Coastal Region, 1975

| County | Gas Capacity[1] (MMCF/D) | Gas Throughput (MMCF/D) | Percent Capacity |
|---|---|---|---|
| Orange | - | - | - |
| Liberty | 117.0 | 53.6 | 45.8 |
| Jefferson | 570.0 | 178.9 | 31.4 |
| Harris | 333.0 | 238.9 | 71.7 |
| Galveston | 219.5 | 163.5 | 74.5 |
| Chambers | 452.0 | 416.1 | 92.1 |
| Brazoria | 2,039.0 | 1,170.3 | 57.4 |
| Matagorda | 1,002.0 | 415.4 | 41.5 |
| Jackson | 111.0 | 150.3 | 135.4 |
| Victoria | 154.0 | 63.8 | 41.4 |
| Calhoun | 231.5 | 126.2 | 54.5 |
| Aransas | 75.0 | 20.0 | 26.7 |
| Refugio | 207.5 | 174.6 | 84.1 |
| San Patricio | 443.8 | 213.4 | 48.1 |
| Nueces | 875.0 | 517.5 | 59.1 |
| Kleberg | 2,692.0 | 1,576.0 | 58.5 |
| Kenedy | 255.0 | 121.0 | 47.5 |
| Willacy | 64.0 | 3.4 | 5.3 |
| Cameron | - | - | - |
| Hidalgo | 459.5 | 157.5 | 34.3 |
| TOTAL | 10,300.8 | 5,760.4 | 55.9 |

1. The capacities at the beginning and end of the year were summed and divided by two to obtain average capacity during the year.

Source: "Gas Processing," International Petroleum Encyclopedia, years 1975 and 1976.

Figure 8

Gas Processing Capacity And Production
U.S. And Texas/1972-1975
(MMCF/D)

| | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Gas Capacity[1] | | | | |
| Texas | 28,882.4 | 29,336.0 | 29,666.9 | 29,236.9 |
| U.S. | 74,198.4 | 73,936.7 | 74,242.1 | 73,284.0 |
| Gas Throughput | | | | |
| Texas | 20,853.2 | 20,138.1 | 19,355.6 | 18,466.5 |
| U.S. | 56,656.1 | 55,624.4 | 53,229.4 | 49,256.9 |
| Percent Utilization | | | | |
| Texas | 72.2 | 68.6 | 65.2 | 63.2 |
| U.S. | 76.4 | 75.2 | 71.7 | 67.2 |

1. The capacities at the beginning and end of the year were summed and divided by two to obtain average capacity during the year.

Sources: Oil And Gas Journal, Surveys of Gas Processing Plants, 1972-1974.

International Petroleum Encyclopedia, years 1975 and 1976.

## 4. IMPACT OF OCS DEVELOPMENT ON THE OFFSHORE EXPLORATORY DRILLING RIG CONSTRUCTION SECTOR

Mobile offshore drilling rigs are used to drill exploratory wells. Four types are currently employed: barges, drillships, jack-ups, and semi-submersibles. The kind actually utilized to drill a given well will depend to a large degree on the depth of water and sea conditions expected. In the Texas Gulf, jack-ups and semi-submersibles are the most common, the former operating in depths up to 350 feet of water, and the latter in up to 2,000 feet.

The demand for drilling rigs is a derived demand, and depends upon the level of exploration. Since rigs are not consumed in the drilling process, but are moved from well to well throughout their 20 to 25 year life expectancy, the demand for new rigs also depends upon the existing supply. Drilling contractors will not order new rigs if there are sufficient rigs to drill the anticipated number of wells. If, however, the demand for rigs exceeds the number available such that profit expectations are high, new rigs will be ordered. Thus, a potential effect of OCS oil and gas development is expansion in the drilling rig construction industry if the demand for new rigs were to exceed the capabilities of the yards to build them.

The offshore exploratory drilling rig market was examined to determine if this is a likely development, and if so, what its impact on the State might be. Specifically, the demand for rigs by type was compared with the supply world-wide and for Texas. The construction capabilities of the Texas yards were also considered. These factors led to the conclusion that OCS development will probably not lead to expanded rig construction capability.

### World Market

The drilling rig market is notoriously cyclical, characterized first by shortages as the tempo of exploration quickens, charters lengthen, and rates rise. In response, contractors may order new rigs. Because of the lead-time required to build the rigs and their long life expectancy, orders are based in part upon expectations concerning the market for 2 and 3 years and longer in the future. As a result, contractors tend to react to a shortage by over-ordering. When these rigs in turn enter the market, the shortage often turns into a surplus as the number of rigs without contracts increases, charters shorten, and rates decline. In short, although demand may rise over time, supply tends to fluctuate around the demand, resulting in periodic surpluses and shortages. The cycle for contractors has been typified as one of feast in one year and famine three years later.

The market is now in the bust phase, a situation due more to overbuilding than to a contraction in offshore exploration. In September, 1973, the total world fleet numbered 230, with 22 idle (10% unemployment) and 90 under construction. As of January, 1977, there was a total of 435 rigs, 65 of which were without contracts (15% unemployment). In addition, 47 were under construction.

A better measure of rig availability can be obtained by considering only the competitive mobile rig fleet, which is comprised of those units that are actually available and able to move from one body of water to another. This excludes tenders, rigs politically tied to an area (for example, the Communist nations), and rigs designed specifically for a given area (Lake Erie, Lake Maracaibo, and Louisiana submersibles). This fleet numbers 318, of which 54 are unemployed (17 percent).

Estimates of demand are available on a yearly basis through 1980. One, by the New Orleans investment company, Howard, Weil, Labouisse, Fredericks, Inc. (Marine Transportation Industry, August, 1976), is displayed in Figure 9. Supply can be readily estimated by considering the existing fleet and those units under construction, and then adjusting for scrappings and losses (historically averaging about 2 percent of the fleet). These results are also shown in Figure 9, as are the consequent surpluses or deficits.

The data suggest that the market will approach equilibrium in 1979, with slight deficits occurring in 1980 (if no new orders are placed). This picture is consistent with current analyses of the offshore rig market. Although estimates of the time that demand will again equal supply range from 1979 to 1982, consensus seems to be that rig supply will not be tight again until the latter part of 1979.

The current market surplus is reflected in construction activity. Virtually no new orders have been placed since mid-1975. Of the 45 jack-ups, semis and drillships under construction, 41 are due to be delivered in 1977, and 30 have no contract. By the time a significant pickup in orders is expected in 1979, the construction yards will be virtually empty. It would appear that a significant number of new orders would have to be placed before construction capacity would be expanded.

Industry analysts agree that exploration off the U.S. coast will provide the best opportunities during the next few years. Several U.S. companies, in fact, have begun bringing rigs back into U.S. waters from overseas.

## Activity in the Texas Gulf

Current leases and announced lease sales were considered with historical exploratory patterns to estimate the demand for rigs off the Texas coast through 1982. Two levels of activity were postulated. The

Figure 9

World Exploratory Drilling Rig Market

| Year | Demand [1] | | Supply [2] | | Surplus (Deficit) | |
|---|---|---|---|---|---|---|
| | Jack-ups | Semis & Drillships | Jack-ups | Semis & Drillships | Jack-ups | Semis & Drillships |
| Beginning 1977 | 150 [3] | 131 [3] | 173 | 159 | 23 | 28 |
| 1978 | 169 | 149 | 185 | 177 | 16 | 28 |
| 1979 | 179 | 168 | 181 | 174 | 2 | 6 |
| 1980 | 184 | 180 | 177 | 171 | (7) | (9) |

1. Demand for beginning 1977 was determined by subtracting the number of rigs without contracts from the total number of rigs. Data source was Offshore Rig Location Report, January 10, 1977. Source for years 1978-1980 was Howard, Wiel, Laouisse, Friedrichs, Inc., Marine Transportation Industry, August, 1976.

2. Source for 1977: Offshore Rig Location Report, January 10, 1977. Supply for other years was estimated by averaging the number at beginning and end of the year, assuming no new orders and a 2 percent scrapping and loss rate.

3. Includes those in port for repair or refitting, or being towed from 1 body of water to another as well as those actually drilling.

first assumed that tracts ultimately explored as a percentage of those leased would be equal to the historical average of 54 percent. The second postulated a higher proportion of 80 percent to reflect post-Embargo energy developments, and thus represents a high impact case.

In addition, both assumed the following:

1. Exploration would be distributed evenly throughout the life of the lease, commencing 10 months after the effective date and ending three months before its expiration.

2. As discussed in Appendix D, the average number of exploratory wells per tract explored in the Texas Federal OCS has been 2.0, and the average number of wells per rig per year has been 1.9.

3. In future sales, 37 percent of the tracts offered will be leased. This has been the average in the Texas OCS sales.

4. Jack-ups will be used in water less than 80 meters and semi-submersibles in water greater than 80 meters in depth.

Figure 10 reveals the anticipated number of wells drilled and rigs required per year under both sets of assumptions. Activity tapers off after 1979 because that is when the current leases start to expire. Although announced Sales 47 and 45 are considered, they are small in magnitude compared with sales such as 34 and 37. Three other sales have been proposed (Sales 51, 58 and 62) and are scheduled over a two-year period beginning in mid-1978. Their impacts were not considered because it is unknown at this time how many tracts will be offered, or even if the sales will take place. When more is known, their effects may be considered by using the approach outlined in this analysis.

The percentage of world demand accounted for by anticipated Texas activity is shown in Figure 11. The low impact case in effect postulated that the Texas OCS share of total demand for jack-ups will increase slightly, while the share of demand for semi-submersibles will actually decline. Under the high impact case, Texas requirements for jack-ups as a percentage of total demand more than doubles. The latter case is perhaps the more likely in view of the fact that 30 percent of all working rigs are employed in the Gulf where the high level of activity is expected to continue, and a growing percentage of the nominated tracts in the announced Gulf lease sales are off the Texas coast.

Current drilling and construction activity for Texas and the Gulf is summarized in Figure 12. There are, for example, 20 jack-ups, including seven in State waters, and 5 semi-submersibles and 3 ships drilling off the Texas coast. In addition, 1 jack-up is in port for refitting, 1 ship is without contract, and 3 jack-ups and 1 ship, all of which are either available or under contract for the Gulf, are scheduled for delivery from the construction yards this year.

Figure 10

Exploratory Wells Drilled/Offshore
Mobile Rigs Required
By Type[1]
1977 - 1982

| | 1977 | | 1978 | | 1979 | | 1980 | | 1981 | | 1982 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jack-ups | Semis | Jack-ups | Semis | Jack-ups | Semis | Jack-ups | Semis | Jack-ups | Semis | Jack-ups | Semis |
| Low Impact Case[2] | | | | | | | | | | | | |
| Total Wells Per Year | 28 | 3 | 37 | 3 | 39 | 6 | 13 | 0 | 8 | 2 | 5 | 0 |
| Total Rigs Per Year | 15 | 2 | 20 | 2 | 21 | 4 | 7 | 7 | 5 | 1 | 3 | 3 |
| High Impact Case[3] | | | | | | | | | | | | |
| Total Wells Per Year | 55 | 16 | 67 | 19 | 69 | 10 | 17 | 2 | 14 | 2 | 6 | 1 |
| Total Rigs Per Year | 29 | 9 | 36 | 10 | 37 | 6 | 9 | 1 | 8 | 1 | 4 | 1 |

1. Considers current leases and announced sales 47 and 45.
2. Assumes that 54 percent of the tracts leased will ultimately be explored (historical average for Texas).
3. Assumes that 80 percent of the tracts leased will ultimately be explored.

Figure 11

Projected Texas OCS Rig Demand As A Percentage Of World Demand

| | Jack-ups | | Semis and Drillships | |
|---|---|---|---|---|
| Year | Number | Percent of Total Demand [1] | Number | Percent of Total Demand [1] |
| Beginning 1977 [2] | 13 | 9% | 8 | 6% |
| 1977 | 15-29 | 10-19% | 2-9 | 2-7% |
| 1978 | 20-36 | 12-21% | 2-10 | 1-7% |
| 1979 | 21-37 | 12-21% | 4-6 | 2-4% |
| 1980 | 7-9 | 4-5% | 1 | 1% |

1. Total demand estimated from Howard, Weil, Labouisse, Friedrichs, Inc., Marine Transportation Industry, August, 1976. See Figure 1.

2. Number operating in Texas Federal waters in the beginning of 1977 was obtained from The Offshore Rig Location Report, January 10, 1977. Estimates in subsequent years are from Figure 2.

Figure 12

Current Status Of Mobile Rigs In The Gulf Region

| | Texas | | Entire Gulf of Mexico [1] | |
|---|---|---|---|---|
| | Jack-ups | Semis and Drillships | Jack-ups | Semis and Drillships |
| Working | 20 [2] | 8 | 49 | 24 |
| Not Working But Under Contract [3] | 1 | 0 | 2 | 1 |
| Without Contract | 0 | 1 | 4 | 5 |
| Under Construction [4] | 3 | 1 | 4 | 2 |
| Total | 24 | 10 | 59 | 32 |

1. Includes Texas
2. Includes seven drilling in State waters
3. Rig is being repaired, refitted, or worked over.
4. These rigs are either without contracts or under contract for the Gulf. Rigs under construction but under contract for another region are excluded.

When this data is compared with the information presented in Figure 10, it becomes apparent that there will be enough semis and ships already in Texas waters to meet the high impact requirements. A sufficient number of jack-ups would be avilable to meet demand under the low impact case, even if those now exploring state waters are excluded, by also considering those in the Gulf region outside of Texas which are being worked over, are without contracts or are under construction and available.

The critical question seems to be the availability of jack-ups under the high impact case, with a projected requirement of 14 more in 1979 than the combined total of those now working in Texas Federal waters, and those not now working or under construction in the entire Gulf region. This demand could be met in one or more of the following ways:

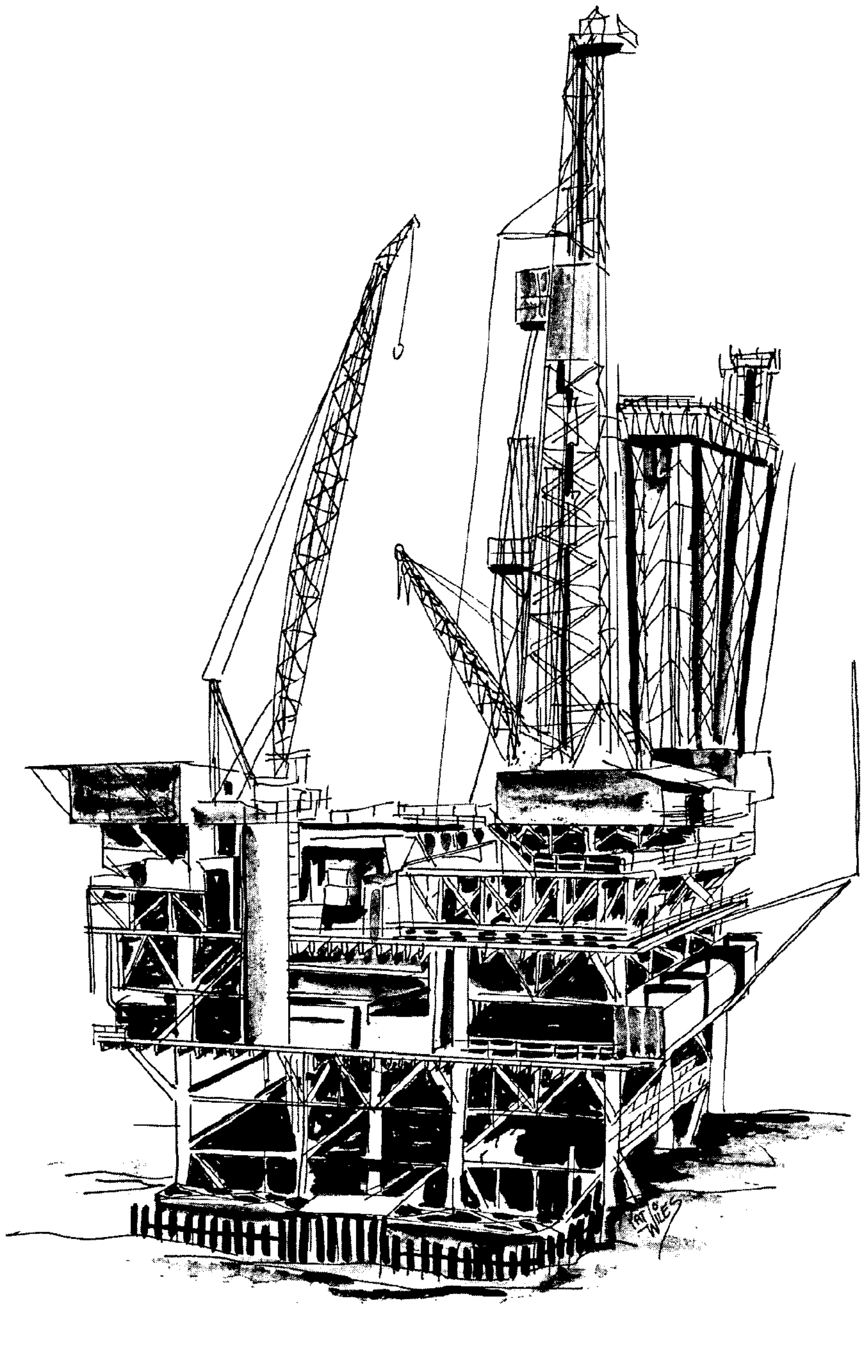
1. Semi-submersibles or barges could be used in place of the jack-ups. Although jack-ups are less expensive than semis and are more suited for shallower water, semis can be substituted if jack-ups are unavailable. In the Gulf off Louisiana, semis rated for 600 feet are now drilling in 20, 40 and 70 feet of water.

2. Jack-ups could be towed in from other regions of the world. Mobile rigs are truly mobile, and rigs have been moved in the past from one area to another. The move is time-consuming and expensive, though. As a result, it is done only if exploration activity in the new area is expected to be sufficiently high to make the move worthwhile. If the market becomes tight enough, a charter may be negotiated whereby the lessee pays the cost.

3. Jack-ups could be constructed in Texas yards or elsewhere. There are five companies in Texas which construct mobile exploratory drilling rigs. Two yards now have no rigs under construction, and with the exception of 1 ship, all orders in the other yards will be delivered by mid-1977. Capabilities of the yards are such that from 12 to 16 deep water jack-ups could be constructed at one time. If the deliveries were scheduled to maximize efficiency, approximately 16 could be built in 2 years, and 26in 3.

Expansion of construction capacity due to OCS development would require a sufficiently high level of exploratory drilling not only to employ the existing fleet, but also to more than fill the currently empty rig order books of the yards in Texas and elsewhere in the Gulf region. The high impact level of exploration projected that more than double the number of rigs currently employed would be required in 1979. Even this demand could be met given the existing supply and yard capacity if the orders were placed now.

As mentioned above, a significant pickup in orders is not anticipated until 1979 when the market is expected to approach equilibrium, given the current supply. It seems reasonable to conclude that if expansion were to occur in yard capacity, it would not be until into the 1980's, and should be a result of much higher levels of exploration in other areas in addition to that off the Texas coast. Expanded exploratory drilling in Texas Gulf would undoubtedly be looked upon favorably by the depressed rig construction industry, but it seems unlikely that Texas OCS development, in and of itself, would warrant an increase in yard capacity.



## 5. IMPACT OF OCS DEVELOPMENT ON FIXED PLATFORM FABRICATION SECTOR

Fixed platforms are used in the development and production phases of an OCS activity sequence. Unlike mobile exploratory rigs, these structures are permanently attached to the ocean floor; they are ordered to be placed at a particular site and are designed to meet the requirements of that location.

As with mobile rigs, the demand for platforms is a derived demand. Since they are special-order items, there is a direct relationship between the number of fields developed and platform demand. The number of platforms needed depends upon the number of discoveries which is economic to develop. The latter, in turn, is determined, at least in part, by the level of exploration and oil and gas prices. If platform requirements were greater than the present capacity of platform fabrication yards, then one may expect expanded capacity as a consequence of oil and gas development.

Estimates of platform demand off the Texas coast were made by considering current leases, announced lease sales, and historical Texas offshore exploration and development patterns. The results are summarized in Figure 13. Two levels of activity were postulated. The low level supposed that tracts explored as a percentage of those leased and tracts developed as a percentage of those explored would be equal to 54 percent and 32 percent, respectively, to reflect historical trends. In contrast, the value of the first proportion was set at 80 percent and the second at 60 percent in the high case in anticipation of accelerated exploration and development.

Other assumptions were made that are common to both:

1. All of the tracts that are developed will be put into production.

2. The platforms that will be installed are drilling/production platforms. In other words, the same platform will be used during both the development and exploration phases.

3. The number of fixed platforms installed per developed tract is 1.6. This has been the average in the Texas Federal OCS, as discussed in Appendix D.

4. Of the tracts offered in announced Sales 47 and 45, 37 percent will be leased. This is in the middle of the historical range for Texas OCS sales.

Figure 13

Fixed Platforms Required
1977-1984

| Year | Low Impact Case | High Impact Case |
|---|---|---|
| 1977 | 14 | 48 |
| 1978 | 18 | 55 |
| 1979 | 17 | 58 |
| 1980 | 18 | 52 |
| 1981 | 13 | 35 |
| 1982 | 5 | 11 |
| 1983 | 2 | 5 |
| 1984 | 1 | 3 |
| TOTAL | 88 | 267 |

NB: This figure considers the impact of lease sales since Sale 31 and announced Sales 47 and 45. Because of the assumptions concerning activity over time, development activity from these sales diminishes after 1980. Development of leases obtained in future, unannounced sales may very well result in the pre-1981 levels continuing rather than tapering off.

5. Tracts already developed are those in which platforms have been set.

6. Platforms will be put in place throughout the period between the 22nd and 82nd months from the effective date of the lease.

The wide range presented in Figure 13 is due to the different assumptions concerning exploratory and developmental activity. The low number reflects a continuation of historical levels, while the high case supposes much more intensive exploration and development. Of course, the level actually achieved will depend upon such variables as federal government energy programs, oil and gas prices, and the nation's relationships with oil exporting countries.

An industry magazine recently published rule-of-thumb multipliers for the Gulf of Mexico OCS which enable one to estimate equipment requirements of future lease sales (Oil and Gas Journal, December 20, 1976). Application of the multiplier of 69 platforms with 2 or more wells per million acres to the Texas OCS results in a requirement of 125 new platforms. The fact that the results are toward the lower portion of the range is to be expected since the multipliers are based on a recent equipment survey and thus reflect current practices for the entire Gulf OCS.

Figure 14 shows the number of platforms installed per year in the Texas Federal OCS and reveals that 15 were installed during 1976. Achievement of the high impact case would thus imply that the number platforms installed per year during the next few years would more than triple. Such a sudden increase seems unlikely when one considers current platform orders and their areas of intended use. This information is presented in Figure 15; it indicates that 16 platforms are specifically intended for Texas federal waters.

The survey upon which Figure 15 is based is 80 percent complete, and thus the data presented underestimates the actual number planned. Even when this is considered, though, the level indicated fits within the range postulated in the low impact case through 1980.

It should be remembered that the time distribution of platform requirements in Figure 13 is based on the assumption that platforms will be installed between the 22nd month and the 82nd month from the effective lease date. This is consistent with the Texas historical average of 52.3 months (Appendix D). Of course, there is nothing dictating that platforms must be installed during this period. Indeed, 295 months elapsed in one case. Thus, if developers encountered constraints on development such as a backlog of orders in fabrication yards, the number needed might very well be spread out over a longer time period. In such a situation, while the platforms installed per year might be about equal to the number postulated in the low impact case through 1980, the level might be sustained for a few more years, thus resulting in more ultimately set in place.

Figure 14

Platforms Installed in Texas OCS by Year[1]

| Year | Number |
|---|---|
| 1955 | 1 |
| 1958 | 1 |
| 1961 | 1 |
| 1962 | 1 |
| 1963 | 5 |
| 1964 | 11 |
| 1965 | 6 |
| 1966 | 4 |
| 1967 | 4 |
| 1968 | 3 |
| 1969 | 3 |
| 1970 | 2 |
| 1971 | 3 |
| 1972 | 3 |
| 1973 | 3 |
| 1975 | 10 |
| 1976 | 15[2] |
| TOTAL | 76 |

1. Source: USGS.

2. Includes one lost in a storm which is due to be replaced.

Figure 15

Platforms Now Under Construction[1]
By Area of Intended
Use/Yard Location

| | Delivery Dates | | | | | |
|---|---|---|---|---|---|---|
| Area of Intended Use | 1976 | 1977 | 1978 | 1979 | Unspecified | Total |
| Texas OCS | 0 | 10 | 1 | 0 | 5 | 16 |
| Other Gulf | 4 | 30 | 2 | 1 | 5 | 42 |
| Location Unavailable, But Built in Gulf Yards | 2 | 6 | 6 | 3 | 2 | 19 |
| **Yard Location** | | | | | | |
| Texas | 2 | 1 | 3 | 1 | 0 | 7 |
| Louisiana | 4 | 41 | 6 | 3 | 5 | 59 |
| Planned for Gulf, But Yard Unavailable | 0 | 4 | 0 | 0 | 7 | 11 |

1. Includes platforms planned, on order, and under construction.

Source: Ocean Industry, January, 1977. Survey is 80 percent complete.

Platforms themselves are built in sections. The lower part is the jacket, made up primarily of welded steel and pinned to the seabed. The upper part is the deck onto which the required drilling and/or development equipment is attached. The entire unit may be fabricated by one yard, or each section may be constructed by different companies.

The U.S. platform construction industry is centered in the Gulf states of Louisiana and Texas, especially the former. These are the major companies:

J. Ray McDermott
Brown and Root
Avondale Shipyard
Teledyne Movible
Dupont Fabricators
Delta Fabricators

Of those, only Brown and Root is situated in Texas. The rest are located in Louisiana.

Figure 15 also outlines construction activity by yard. It shows that platforms known to be ordered from Gulf Coast yards number 66, of which 7 (11 percent) were placed with the Texas company. The delivery dates of a few extend into 1979. A comparison of these orders with the total annual capacity (which has been estimated by industry analysis to be between 60 and 70) seems to indicate that some surplus capacity exists in the industry. However, although the survey upon which the order information is based is the most comprehensive one available, it is still only 80 percent complete, leading one to conclude that less slack exists in the industry.

The industry has expanded within the past few years. Additions include a second Brown and Root yard in Texas, located near Corpus Christi; expansion of yards in Houma and New Iberia, Louisiana, and of Avondale's yard in Morgan City, Louisiana; and a new facility at Intercoastal City, Louisiana.

Conversations with industry analysts and individuals within the industry reveal that while order books should remain full, a significant expansion in capacity will probably not occur during the next few years. Any increase which does take place will most likely take the form of expansion of existing facilities rather than construction of new yards. Such a growth pattern implies that the bulk of expanded activity would occur in Louisiana rather than in Texas.

In summary, these conclusions can be drawn concerning the probable impact of Texas OCS development on the platform fabrication industry in Texas.

1. In the high impact case the number of platforms installed annually is more than triple current levels, whereas in the low impact case

the number set in place increases only slightly. Present orders for platforms point to an annual level for the next several years close to the latter case rather than to a significant increase, and thus seem to confirm the validity of the low impact case for the near term.

2. Levels of exploration and development approaching the high impact case could result from specific government policy actions. For example, the decontrol of natural gas prices could make some marginal reserves economic and thus open more areas for development. Of course, whether such policy changes will actually occur is unknown. Considering present order books and expected capacity increases, it seems reasonable that a high level of activity would be reflected in slightly increased annual installations extended over a longer period of time in lieu of a high number installed within the relatively short time-span of Figure 13. Such an order pattern would be more easily absorbed by present industry capacity.

3. The expected growth pattern is one of minor capacity increases due primarily to expansion of existing facilities. Since only one company is located in Texas, such a case implies that the effects of any expanded fabrication capacity due to Texas OCS development would be felt primarily by Louisiana.

As discussed above, demand for fabrication yards depends upon the demand for platforms which in turn depends upon the rate and extent to which field are developed. Since platforms are special order items, there is no pre-existing supply. Rather, demand for platforms is translated directly into orders. Unfortunately, one encounters data problems at this point. Information about such basic matters as yard capacity and cureent orders by shipyard, by delivery date, and by area of intended use tend to be incomplete, contradictory, or unavailable. In addition, unlike during the exploration phase, companies are not required to develop a field and put it into production during a specific time period. This also increases the difficulty of forecasting demand. Because of these factors, the conclusions drawn in this analysis are less definitive than those reached in the other industry analyses.

# 6. IMPACT OF OCS OIL AND GAS DEVELOPMENT ON PETROCHEMICAL PLANTS

Very broadly defined, petrochemicals are those products derived from petroleum and natural gas. They generally are considered to consist of three components: basic petrochemicals (those made directly from petroleum and natural gas fractions), intermediates (those for which a definite chemical precursor can be identified and which will undergo further chemical reactions), and end products such as fibers, plastic resins and rubber. The last does not include fabricated products like plastic articles and tires.

Crude oil and field natural gas are not used directly by the industry, but are processed first by refineries and gas processing plants. The petrochemical industry thus does not produce hydrocarbons but rather purchases liquified hydrocarbon products and processed natural gas to be used as feedstocks or raw materials.

The major petrochemical feedstocks are natural gas; liquified petroleum gases (LPG) such as ethane, propane and butane; and heavy liquids such as naptha and gas oil. The LPG's are produced in refineries or extracted at gas processing plants; the heavy liquids are refinery products.

Total Texas production in 1975 of feedstock products is summarized in Figure 16. Not all of the products are used solely as feedstocks. For example, while most of the ethane and all of the iso-butane are utilized as petrochemical raw materials, propane, butane and natural gas have other applications. Thus, the industry must compete with other consumers of natural gas, natural gas liquids, and refined products for their feedstocks.

Competition for refined products is not limited to particular LPG's such as propane or butane. Petrochemical manufacturers also compete with users of all possible products from a barrel of crude, since crude oil can be refined into a multitude of refined products. The percentages of refinery yields used as feedstocks are presented in Figure 17 for Texas and the U.S. Even though the yield from Texas refineries (8.1 percent) is more than double the national average, the bulk of refinery output is not used as petrochemical feedstock.

Consumption of feedstocks by the industry in Texas has been estimated by the Texas Governor's Energy Advisory Council; this information is shown in Figure 18 for 1975 both as absolute values and as percentages of total Texas production. The industry in Texas thus consumed amounts equal to about 55 percent of the state's production of LPG, 91 percent of the production of heavy liquids, and 2 percent of natural gas production.

Figure 16

1975 Texas Production of Products Which Are Used As Major Petrochemical Feedstocks (MB)

| | Texas Gulf | Texas Inland | Total |
|---|---|---|---|
| Natural Gas (BCF)[1] | NA | NA | 7,486 |
| Liquified Petroleum Gases[2] | | | |
| Ethane | 17,440 | 45,893 | 63,333 |
| Refineries | 2,609 | 80 | 2,689 |
| Gas Processing Plants | 14,831 | 45,813 | 60,644 |
| Propane | 37,525 | 79,784 | 117,309 |
| Refineries | 21,027 | 2,886 | 23,913 |
| Gas Processing Plants | 16,498 | 76,898 | 93,396 |
| Butane | 11,956 | 36,980 | 48,936 |
| Refineries | 5,593 | 595 | 6,188 |
| Gas Processing Plants | 6,363 | 36,385 | 42,748 |
| Butane-Propane Mix | 625 | 1,326 | 1,951 |
| Refineries | 121 | 15 | 136 |
| Gas Processing Plants | 504 | 1,311 | 1,815 |
| Iso-Butane | 6,548 | 9,625 | 16,173 |
| Refineries | 2,068 | 73 | 2,141 |
| Gas Processing Plants | 4,480 | 9,552 | 14,032 |
| Total LPG | 74,094 | 173,608 | 247,702 |
| Refineries | 31,418 | 3,649 | 35,067 |
| Gas Processing Plants | 42,676 | 169,959 | 212,635 |
| Petrochemical Feedstocks[2] | 68,866 | 8,955 | 77,821 |

1. Marketed production of natural gas. Taken from Bureau of Mines, Mineral Industry Surveys, Natural Gas Production and Consumption: 1975 (annual), October, 1976. Breakdown between Texas Gulf and Texas Inland was not given.

2. Taken from Bureau of Mines, Mineral Industry Surveys, Crude Petroleum, Petroleum Products, and Natural Gas Liquids: 1975 (Final Summary), February, 1977, p. 17. The category Petroleum Feedstocks consists of all feedstocks produced by refineries other than those listed under LPG.

Figure 17

Percentage of Refinery Yields Accounted For By Petrochemical Feedstocks, Texas And The U.S., 1975[1]

| | Texas Gulf | Texas Inland | Total Texas | Total U.S. |
|---|---|---|---|---|
| Total Crude and Unfinished Runs (MMB) | 1,031 | 160 | 1,191 | 4,554 |
| LPG | 1.7%[2] | 0.3 % | 1.5% | 0.7 % |
| Ethane | 0.3% | 0.05% | 0.2% | 0.09% |
| Other LPG (Chemical Use Only) | 1.5% | 0.2 % | 1.3% | 0.6 % |
| Other Petrochemical Feedstocks | 6.7% | 5.6 % | 6.5% | 2.7 % |
| Total Yield Accounted For By Feedstocks | 8.4% | 5.9 % | 8.1%[2] | 3.4 % |

1. Yields from crude and unfinished oil reruns. Data derived from Bureau of Mines, Mineral Industry Surveys, Crude Petroleum, Petroleum Products and Natural Gas Liquids: 1975 (Final Summary).

2. Totals do not add due to rounding.

Figure 18

Consumption of Feedstock By The Petrochemical Industry In Texas During 1975

| | Consumption[1] | As Percentage of Texas Production[2] |
|---|---|---|
| LPG (MMB) | 136 | 55% |
| Heavy Liquids (MMB) | 71 | 91% |
| Natural Gas (Billion C F)[3] | 143 | 2% |

1. Source: State of Texas Governor's Energy Advisory Council.
2. Derived by dividing consumption data by production data found in Figure 1.
3. Consumption as a percentage of total Texas consumption is 3.3%.

Proximity to secure feedstock supplies is an important location factor, especially for the makers of basic and intermediate petrochemicals. For example, in one study of petrochemical plants in Texas, 47 out of 60 firms ranked "nearness to raw materials" as the primary site selection factor (Whitehorn, 1973). Since Texas is the largest producer of natural gas and has 26 percent of the U.S. refining capacity, it is not surprising to discover that a large portion of the nation's basic chemical capacity is located within the state. Figure 19 compares Texas' capacities for major basic chemicals with total U.S. capacities and reveals that, with the exception of ammonia, at least 40 percent of production capacity for each product is found in Texas.

The industry within Texas is concentrated in the coastal region, as Figure 20 indicates. The 56 plants in the area constitute 69 percent of the number in Texas, and 17 percent of the number in the U.S. Also, 45 percent of the nation's announced construction projects are planned for the Texas coastal region.

The survey upon which Figure 20 is based focuses on the basic and intermediate segments of the industry and thus may be incomplete. An earlier, broader survey identified 82 firms operating 139 plants, of which 67 percent by number and 88 percent by capacity were located in the Coastal Zone (Whitehorn, 1973).

Figure 19

Basic Chemical Capacity, 1975
MM Lbs/Yr.

| Product | Texas Capacity | Continental U.S. Capacity | Texas as a Percentage of U.S. |
|---|---|---|---|
| Ethylene | 15,310 | 24,895 | 61% |
| Propylene | 6,235 | 13,510 | 46% |
| Butadiene | 3,295 | 3,965 | 83% |
| Acetic Acid | 1,140 | 1,140 | 100% |
| Butyl Rubber | 180 | 385 | 47% |
| Polybutene | 280 | 460 | 61% |
| Butyl Alcohol | 192 | 459 | 42% |
| Benzene | 3,859 | 7,674 | 50% |
| Toluene | 5,009 | 7,180 | 70% |
| Xylenes | 3,123 | 4,191 | 75% |
| Carbon Black | 1,865 | 4,223 | 44% |
| Ammonia | 6,867 | 37,566 | 18% |
| Methanol | 5,350 | 8,354 | 64% |
| TOTAL | 52,705 | 114,002 | 46% |

Source: Texas/Louisiana Petrochemicals, prepared for the Petrochemical Energy Group (Houston: Groppe and Long, June, 1975).

Figure 20

Location of Texas Petrochemical
Plants By Region

| County | Number of Plants: Operating[1] | Under Construction[2] |
|---|---|---|
| Gulf Coast | 56 | 31 |
| Orange | 4 | 1 |
| Jefferson | 9 | 3 |
| Chambers | 1 | 0 |
| Harris | 25 | 14 |
| Galveston | 5 | 3 |
| Brazoria | 5 | 3 |
| Matagorda | 1 | 1 |
| Calhoun | 1 | 1 |
| Victoria | 0 | 1 |
| Nueces | 4 | 3 |
| Cameron | 1 | 0 |
| Unspecified | 0 | 1 |
| Inland | 25 | 0 |
| TOTAL | 81 | 31 |

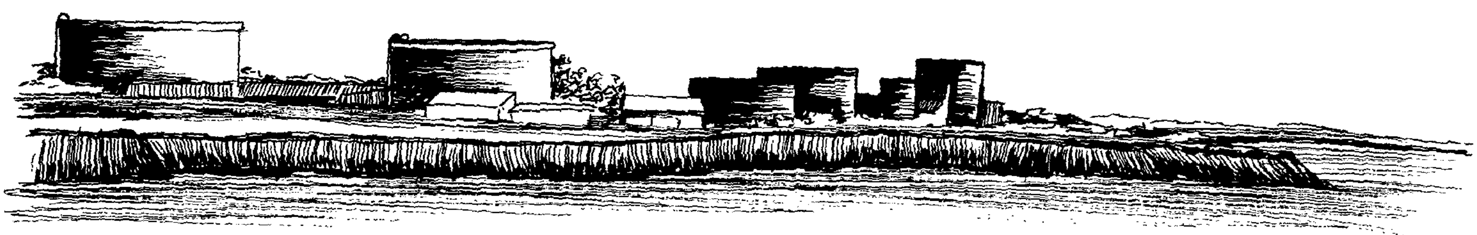
1. Taken from International Petroleum Encyclopedia (Tulsa, OK: Petroleum Publishing Co., 1976).

2. Includes projects which are planned, proposed, or under construction. Taken from the following issues of Oil and Gas Journal: 4 October 1976, 29 November 1976, 6 December 1976.

It should be emphasized that the petrochemical industry is an energy consuming industry in that it depends upon refineries, gas processing plants, and other petrochemical plants for its feedstocks; it does not process crude oil or field natural gas. Moreover, the percentage of crude oil or natural gas ultimately used as feedstock is relatively small. For example, only about 8 percent of the refinery yields from crude and unfinished oil reruns in Texas is accounted for by petrochemical feedstocks. Further, consumption of natural gas in Texas as feedstock equals approximately 2 percent of Texas production.

The critical question concerning the impact of OCS development on the petrochemical industry would seem to be this: Would the expected expansion in refining and gas processing capacities due to an increase in OCS crude oil and field natural gas production justify new petrochemical capacity, considering, of course, the importance of proximity to raw materials as an important site selection factor? As discussed elsewhere in this volume, no expansion of refining and gas processing capacities is expected as a result of OCS oil and gas development. Rather, new OCS oil will probably replace foreign crude currently being imported into state refineries; the increased OCS gas production should be enough to reverse downward trends in total OCS gas production and the coastal region's gas processing capacity utilization but insufficient to require significant new capacity. Since the sectors upon which the petrochemical industry depends for its raw materials are not expected to experience increased capacities, it seems reasonable to conclude that expansion in the petrochemical sector because of OCS oil and gas development is unlikely.

In Texas, the onshore industrial sectors such as refining, gas processing, and petrochemicals which are dependent upon crude oil and natural gas either directly or indirectly are fully developed. Consequently, further OCS development will not automatically result in new plants being established. Indeed, investigation has pointed out the improbability of such expansions occuring primarily as a result of OCS development. This contrasts with OCS frontier areas where few, if any, of these types of plants operate and therefore where expansion of these sectors is far more likely.



## 7. IMPACT OF OCS DEVELOPMENT ON PETROLEUM STORAGE FACILITIES

The nation's physical petroleum distribution network consists of two subsystems. As part of the primary system, pipelines, tankers, and barges are used to transport crude oil to refineries and refined products in bulk from these centers to bulk terminals. In the secondary system, trucks, barges, railcars, and pipelines are employed to move products from terminals to bulk stations and ultimately to the final consumers.

Petroleum storage facilities are important components of the total network, for crude oil and refined products are first accumulated at these facilities and then segregated, batched, and inventoried for further movement through the system. The facilities are also used to hold crude oil and products between the time of production and time of final use.

The latter function is especially important for motor gasoline and distilllate fuel oil. Demand for these products is seasonal, and supply is relatively constant. As a result of the time discrepancy, inventories must be built up each year prior to the period of peak demand, a process usually occurring around the end of March and during October for gasoline and fuel oil, respectively. The inventories are then drawn down during the peak demand seasons.

There are at least two major sources of information on storage capacity. The first is a survey conducted periodically by the National Petroleum Council (NPC). This survey provides data on primary storage capacity and utilization; the latest was conducted in 1973.

The second is the Petroleum Bulk Stations and Terminals section of the Census of Whole Trade. The Census is undertaken every five years; the most recent was in 1972. Information is given concerning the storage capacities of bulk terminals and bulk stations. The former are part of the primary system while the latter are components of the secondary system. Data on bulk terminals are thus provided by both sources. The Census may be more complete than the NPC survey in terms of number of establishments included but, unlike the NPC study, provides no information on utilization.

Primary capacity and utilization in Texas are shown in Figures 21 and 22. Crude storage capacity consists of tankage at refineries, along pipelines, and on tank farms. Refined product storage capacity encompasses the tankage at refineries, along pipelines and on tank farms, and at bulk terminals which have been assigned to the following products: motor and aviation gasoline, kerosene, jet fuel, distillate fuel oil, and residual fuel oil.

Since the NPC survey only provides crude storage information by Petroleum Administration for Defense (PAD) Districts, capacity in Texas was

Figure 21

Primary Storage Capacity
As Of
September 30, 1973
(MB)

| | Inland Texas | Gulf Texas | Total Texas |
|---|---|---|---|
| Crude[1] | NA[2] | NA | 131,355 |
| Refineries | NA | NA | 33,592 |
| Pipelines and Tank Farms | NA | NA | 97,763 |
| Product[3] | 32,021 | 96,655 | 128,676 |
| Refineries | 24,001 | 81,916 | 105,917 |
| Pipelines and Tank Farms | 1,669 | 9,561 | 11,230 |
| Bulk Terminals | 6,351 | 5,178 | 11,529 |

1. Crude storage capacity by PAD districts was given in the NPC study. Capacity for Texas was estimated by assuming that the ratio of Texas capacity to total District III capacity was equal to the ratio of Texas crude stocks to total District III crude stocks on that date. The source for the latter ratio was Bureau of Mines, Crude Petroleum, Petroleum Products, and Natural Gas Liquids: 1973 (Final Summary), Mineral Industry Surveys, February, 1975.

2. NA means not available.

3. Taken from National Petroleum Council, Petroleum Storage Capacity, September 10, 1974.

Figure 22

Primary Storage Utilization
As Of
September 30, 1973
(MB)

| | Crude | Product |
|---|---|---|
| **Texas Inland** | | |
| Capacity[1] | NA[2] | 32,021 |
| Amount In Tanks[3] | NA | 10,910 |
| Percent Full | NA | 34.1% |
| **Texas Gulf** | | |
| Capacity[1] | NA | 96,655 |
| Amount In Tanks[3] | NA | 52,720 |
| Percent Full | NA | 54.5% |
| **Texas Total** | | |
| Capacity[1] | 131,355 | 128,676 |
| Amount In Tanks | 72,473[4] | 63,630 |
| Percent Full | 55.2% | 49.4% |

1. Taken from Figure 21.
2. NA means not available.
3. Source: NPC, Petroleum Storage Capacity, September 10, 1974.
4. Source: Bureau of Mines, Crude Petroleum, Petroleum Products, and Natural Gas Liquids: 1973 (Final Summary), Mineral Industry Surveys, February, 1975.

estimated by assuming that the ratio of Texas capacity to total District III capacity (of which Texas is a part) was equal to the ratio of Texas crude stocks to total District III crude stocks on that date. A comparison of this result with crude stocks (information reported by the Bureau of Mines) gives an estimate of capacity utilization of 55 percent.

Product storage capacity and utilization are available by Bureau of Mines Refining Districts; thus a breakdown between inland Texas and the Texas Gulf region is available. Close inspection of Figure 21 reveals that most of the capacity in the Gulf region is located at the refineries and along pipelines or on tank farms; that is, it is found toward the producing end of the distribution system. Of the total State capacity in these two categories, 77 percent and 85 percent respectively are in the coastal region. In comparison, the area has 45 percent of Texas' tankage at bulk terminals. The large amount of capacity at refineries is not surprising when one realizes that Texas coastal counties have 86 percent of the State's refining capacity, and 23 percent of the nation's.

Utilization of the tankage assigned to refined products averaged 55 percent for the Gulf region, and 49 percent for the entire State.

Figure 23 summarizes the capacity of bulk stations and terminals by county. Terminals are all those facilities having total bulk storage capacity of 50 MB or more and smaller units which receive their products primarily by tanker, barge, or pipeline. When the total census capacity of the coastal counties of 6,403 MB is compared with the NPC estimate for the region of 5,178 MB, it can be seen that most of the area's census storage capacity is at terminals and thus part of the primary system, rather than at stations.

A further disaggregation of Figure 23 which would distinguish between terminal and station capacity for each county is not available. In the entire State, there are 2,077 stations with a total capacity of 3,679 MB and 80 terminals with tankage of 12,636 MB. In other words, most of the storage capacity in Texas is part of the primary system; this is especially true in the Gulf region.

As discussed elsewhere in this volume, new OCS crude oil can reasonably be expected to replace foreign crude currently being imported into state refineries. Since, in such a case, the new crude oil will not represent a net increase in the total flow through the system, new storage facilities should not be required due to Texas Federal OCS activities.

Unfortunately, information concerning storage capacity and utilization is limited. The two sources which are available are published relatively infrequently, creating data problems if one's study does not happen to be undertaken immediately after publication of the latest Census or Survey. In short, although the data sources used are not as current as other data cited in this study, they represent the most recent research efforts in this area.

Figure 23

Storage Capacity Of Petroleum Bulk Stations And Terminals, 1972[1]
(MB)

| County | Number | Capacity |
|---|---|---|
| Gulf Coast | 315 | 6,403.0 |
| Orange | 6 | 14.0 |
| Liberty | 14 | 20.1 |
| Jefferson | 18 | 109.1 |
| Harris | 68 | 4,930.3 |
| Galveston | 13 | 100.9 |
| Chambers | 8 | 15.0 |
| Brazoria | 30 | 29.7 |
| Matagorda | 18 | 16.5 |
| Jackson | 5 | 10.8 |
| Victoria | 11 | 106.2 |
| Calhoun | 7 | 8.7 |
| Aransas | 3 | 4.3 |
| Refugio | 4 | 7.1 |
| San Patricio | 12 | 11.3 |
| Nueces | 24 | 585.9 |
| Kleberg | 6 | 8.6 |
| Kenedy | - | - |
| Willacy | 7 | 7.5 |
| Cameron | 31 | 366.3 |
| Hidalgo | 30 | 50.7 |
| Inland | 1,842 | 9,912.2 |
| Total | 2,157 | 16,315.2 |

1. Taken from Bureau of Census, 1972 Census of Wholesale Trade. Capacities were converted from gallons to barrels (42 gallons to a barrel) to facilitate comparisons with other figures.

# OFFSHORE OIL:

# ITS IMPACT ON TEXAS COMMUNITIES

VOLUME IV
APPENDICES

Texas Coastal Management Program
General Land Office of Texas
Bob Armstrong, Commissioner

prepared by

Research and Planning Consultants, Inc.
Austin, Texas
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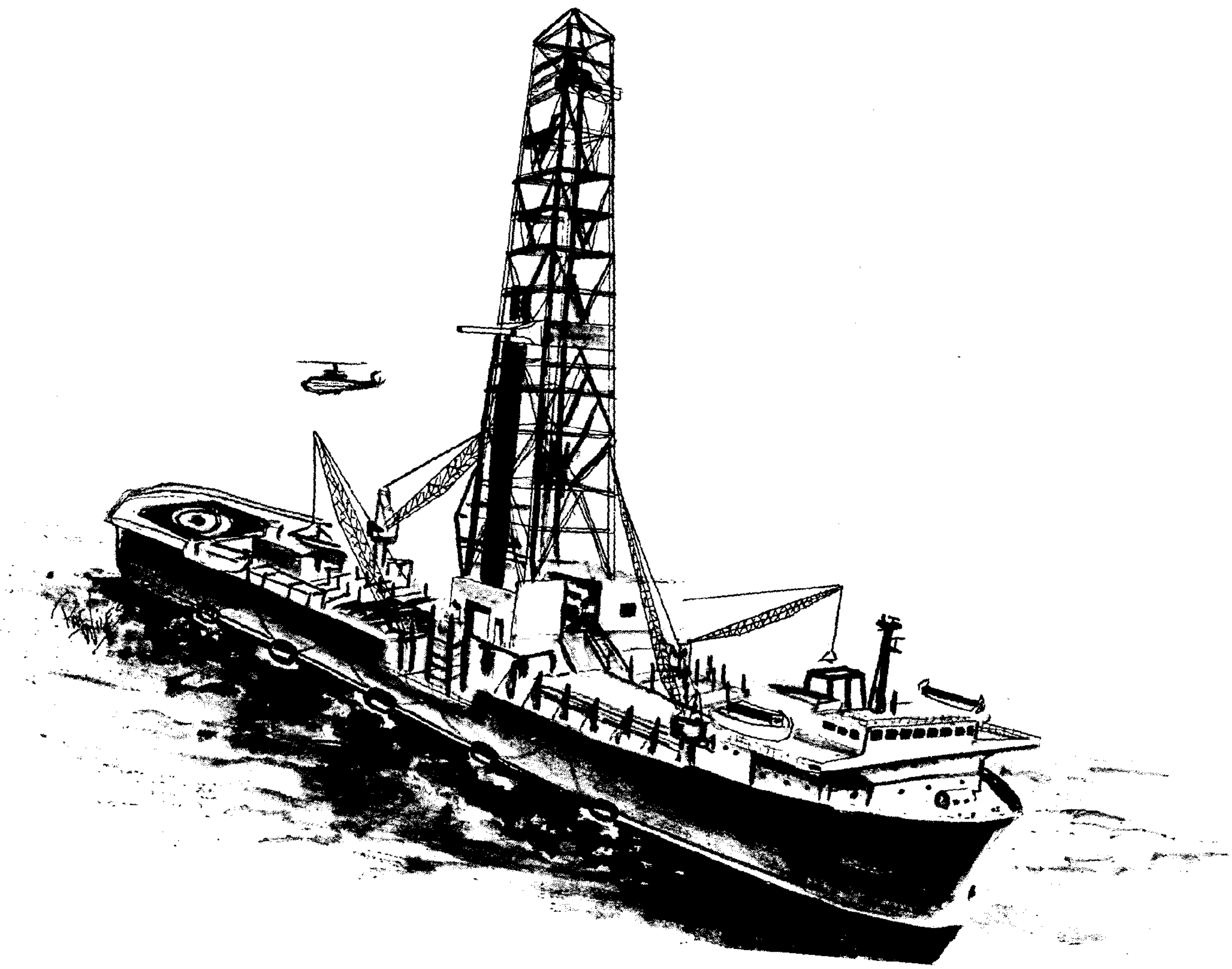
VOLUME IV: APPENDICES

## ACCOMPANYING VOLUMES

# APPENDIX A

# STUDY METHODOLOGY



## INTRODUCTION

The Outer Continental Shelf (OCS) Oil and Gas Development Impact Methodology was developed by RPC, Inc. for the Texas General Land Office as part of a project to (1) develop a methodology to determine impacts of OCS oil and gas development and (2) using that methodology, evaluate the Texas onshore and nearshore impacts of OCS oil and gas development. This methodology is one of several documents prepared by RPC, Inc. during Phase I of its study. The analysis of OCS impacts is, in turn, one of several special projects of the Coastal Management Program of the Texas General Land Office

The Impact Methodology is actually seven separate methodologies: A through G (see Figure A1). Each methodology is divided into tasks; each task is described on a separate page in the document. Tasks for Methodology A are serialized A1, A2, A3, etc.; tasks for Methodology B are referenced as B1, B2, B3; and so on. The tasks are described with respect to their objectives, the inputs necessary for their conduct, the activities included, task outputs, and the use of the task outputs.

Task outputs include "internal memoranda" (memos) which are informal presentations of results; and "products," which are brief but formal reports. Both types of outputs are identified in the text by the task designation and one further number following the decimal point which distinguishes between multiple outputs of a single task. Of these outputs, only the "products" are shown in Figure A1.

Methodology A, Scenario Description, has as its ultimate purpose the development of Texas Federal OCS development scenarios. Each scenario derived from Methodology A is correctly seen <u>not</u> as a prediction, but as a postulation of OCS oil and gas development to be used only for the purpose of determining the impacts of the postulated activities if they were to actually occur. That is, each scenario is a postulated event - not an actual or a predicted event - which will be analyzed in Methodologies B through G.

Methodologies B, C, and D provide for determination of the direct and indirect onshore effects of each scenario's exploration, development, and production phase, respectively.

Methodology E provides for the determination of net onshore effects of offshore exploration, development, and production over time by region and for the State of Texas as a whole. It results in net state economic impact and net local economic impact.

Methodology F provides for an assessment of the environmental impact of each scenario; Methodology G provides the same for social impact.

The use of scenarios as an analytic tool is not new, nor is the analysis of the impact of impending commercial or industrial developments a novel concept. This impact methodology does, however, combine several analytical techniques which have been used by themselves in other studies at other times, to result in an approach which, in its totality, is singular and is characterized by several distinguishing features.

1. The methodology provides for the determination of three separate categories of impact: economic (including infrastructural), environmental, and social.

2 The methodology provides for the determination of those three categories of impact both by region and State.

3. The methodology utilizes a refinement of the Texas input/output model to derive regional and State impacts.

4. The methodology is adaptable not only to other geographical areas, but to other developments (either OCS-related or non-OCS related) as well.

Finally, it should be noted that time and funding limitations prevented the development and use of a rigorous and detailed methodological approach which would provide a comprehensive identification and explicit analysis of all the manifold economic, social, and environmental effects of the postulated OCS development scenarios. Numerous simplifications were necessary which omitted various known but minor interrelationships, effects, and costs. Within the constraints of the simplifications made, however, the described methodologies provide the fullest accounting of effects and costs consistent with project scope. Each methodology has been organized so as to facilitate its later extension as a basis for more detailed studies.

## METHODOLOGIES

### A. Scenario Description Methodology

The methodology employed for Scenario descriptions is shown in Figure A1. It comprises four tasks; namely, the interpretation of available data relating to potential OCS reserves (A1); the description of postulated strikes (A2); an analysis of industry practices involved in OCS exploration, development, and production (A3); and the preparation of scenario descriptions (A4).

Task A1 - Interpretation of Available Data

Objective: To identify the range in the size, location, likelihood, and characteristics of an OCS strike which could reasonably occur.

Input:

- information on the number and dates of lease sales to be held based on BLM projections;
- estimates, largely from federal agencies, of the total recoverable reserves of oil and gas in the federal OCS off Texas;
- geologic description of each producing trend prepared by the Bureau of Land Management, U.S. Department of the Interior;
- present trends of production in the Texas OCS area and the federal OCS area off Texas derived from data supplied by the Texas General Land Office, the United States Geological Survey, the Bureau of Land Management, and the Texas Railroad Commission;
- description of existing pipelines and proposed pipelines from data of the Texas General Land Office, the Federal Power Commission, and private industries;
- data on the location and extent of exploratory drilling presently under way in the OCS area derived from USGS and BLM data, and other publications;
- data on overall energy supply, pricing, and other matters.

Activities: Collection, organization and analysis of the available information (including that obtained from interviews) to determine the reasonable ranges in location, scale, and other characteristics of a strike.

Output: An internal memorandum (memo A1.1) describing the available information and data and the conclusions of analysis with respect to the range of:

- tracts to be offered for lease in each sale;
- tracts to be leased as a percentage of tracts offered;
- tracts to be explored as a percentage of tracts leased;

- tracts developed as a percentage of tracts explored;
- tracts put into production as a percentage of tracts developed;
- location and size of tracts put into production;
- oil/gas ratio; and
- assumptions concerning overall energy supply, international pricing, and other matters affecting the timing and manner of exploration, development and production.

Use: Memo A1.1 will be the principal input to Task A2, Description of a Strike.

Task A2 - Description of a Strike

Objective: To describe the general characteristics of a series of postulated strikes.

Input: Internal memorandum A1.1 describing reasonable ranges in the location, nature, and extent of a potential OCS strike and subsequent production.

Activities: Postulate several alternative strikes which provide a range in the assumptions of location, size, and other characteristics.

Output: An internal memorandum (memo A2.1) describing each postulated strike with respect to:

- hypothesized number and location of tracts offered for lease in each sale,
- hypothesized number and location of tracts actually leased in each sale as a percentage of tracts offered,
- hypothesized number and location of tracts actually explored as a percentage of tracts leased,
- hypothesized number and location of tracts actually developed as a percentage of tracts explored,
- hypothesized number and location of tracts which will produce as a percentage of tracts developed,
- hypothesized amount of production from producing tracts, including any previous activity not included in hypothesis above, and
- assumptions related to overall national energy supply.

Use: Memo A2.1 will provide a partial basis for the descriptions of scenarios to be developed in Task A4.

Task A3 - Industry Practices

Objective: To identify the likely time scheduling of activities and requirements of various types related to alternative OCS development patterns.

Input:

- USGS and BLM documents;
- other relevant books, articles, and reports;
- information collected by interview with private industries;
- analysis of current and previous experiences in other federal OCS areas;
- data relating to the sensitivity of private investors' OCS development decisions to government policy variables.

Activities: Analyze the available information and describe the most likely sequence, scheduling and types of activities for each described strike and development pattern including:

- the time period and equipment involved in seismographic exploration,
- the time period in which lease sales take place,
- the time period for exploratory drilling,
- number and type of exploratory wells per explored tract,
- number and type of exploratory wells per rig per year,
- time sequence between exploratory drilling and development drilling,
- number of platforms per developed tract,
- number of development wells per platform,
- number of development wells per platform per year,
- time sequence between development and production,
- number of platforms per producing tract,
- number of production wells per platform,

- transportation and storage facilities utilized and the time sequence of their construction or expansion, and

- operations and maintenance practices.

Output: An internal memorandum (memo A3.1) including a tabular listing of requirements, scheduling, and other characteristics of the development patterns associated with each postulated strike.

Use: Memo A3.1 will provide a partial basis for the description of scenarios prepared in Task A4 and will serve as input to Tasks B1, C1, and D1.

Task A4 - Preparation of Scenarios

Objective: To describe the OCS development scenarios to be evaluated.

Input:
- memo A2.1 describing the characteristics of each postulated strike (or set of strikes); and
- memo A3.1 describing the characteristics and requirements of the development pattern likely to accompany each postulated strike.

Activities:
- Prepare comprehensive scenarios combining strike characteristics and development pattern characteristics;
- Assure the internal consistency of each scenario; and
- Prioritize the scenarios for evaluation based on their estimated likelihood of occurance but giving high priority to at least one large scale development.

Output: Product A4.1 which describes each scenario and the prioritized listing of scenarios for evaluation.

Use: Product A4.1 provides the basis for the development of the sub-scenarios for exploration (Task B1), development (Task C1) and production (Task D1).

## B. Exploration Methodology

The exploration methodology provides for determination of the primary and indirect onshore effects of the offshore exploration phase associated with each scenario evaluated. The interrelationship of the several tasks comprising the methodology is shown in Figure A1.

As noted on Figure A1, Task B1 (Exploration Sub-Scenario Description) and Task B2 (Distribution of Requirements to Coastal Study Sites) require consideration of any or all study sites which might be significantly affected by exploration activities or provide some part of the exploration requirements. Subsequent tasks in the exploration methodology deal with each affected study site. In the event a hypothesized exploration sub-scenario affects more than study site, Tasks B3 through B9 would be repeated for each site.

Task B1 - Exploration Sub-Scenario Description

Objective: To describe the requirements over time of the exploration phase of a scenario with respect to requirements for land, personnel, facilities, services, and supplies.

Input:
- description of the scenarios and development patterns which are to be evaluated (product A4.1), and
- description of industry practices (memo A3.1).

Activities:
- Prepare a general description of the type, extent, and timing of exploration assumed to take place; and
- Use available information on industry practices and characteristics of the postulated scenarios to calculate significant requirements over time for rigs and other equipment, land for construction of needed equipment and operation, personnel for conduct of exploration activities including those required for primary facilities, services, and supplies.

Output: An internal memorandum (memo B1.1) including descriptions of the exploration pattern for each scenario and a tabular listing of significant exploration phase requirements over time for each scenario without regard to the source or location from which requirements will be met.

Use: Memo B1.1 is a partial basis for the distribution of exploration phase requirements to study sites.

Task B2 - Distribution of Requirements to Study Sites

Objective: To distribute the significant exploration phase requirements, over time, to each affected study site.

Input:

- memo B1.1, which describes the exploration sub-scenario including primary land and manpower requirements over time; and requirements for significant primary facilities, services, and supplies over time; and

- information concerning the current availability and accessibility of those resources in each affected study site as determined from Department of Commerce documents (pertaining to relevant SIC's); baseline economic, demographic, natural resources, and infrastructural inventories; and the study sites' development goals.

Activities:

- Determine the availability and accessibility of resources in each affected study site based on both a survey of existing resources in the site and on consideration of the feasibility of drawing on those resources ("available and accessible" will mean "usable" as well as "existing"); and

- Allocate the resource demands to each affected study site based on their availability and accessibility. Where alternative locations for development exist within a study site, a sub-allocation of requirements will be made.

Output: Three outputs:

- primary land requirements (product B2.1);

- primary manpower requirements (product B2.2);

- significant primary facilities, services, and supplies requirements (memo B2.3).

The primary land requirements, (product B2.1) will describe the allocation of primary land requirements by type of use and amount, over time, for each affected study site.

The primary personnel requirements (product B2.2) will describe the allocation over time of primary personnel requirements for each affected study site.

The memorandum on requirements for significant primary facilities, services, and supplies (memo B2.3) will detail the cumulative requirements for the exploration phase by study site and over time.

Use: Information contained in products B2.1, B2.2 and memo B2.3 will be input directly into the determination of primary and indirect land requirements (Task B4); primary and indirect employment (Task B7); and primary facilities services and supplies requirements (Task B3) for each affected study site. In addition, Product B2.2 will be input to Task B5, Preparation of Input to I/O Model.

Task B3 - Primary Facilities, Services, and Supplies Requirements

Objective: To identify requirements and revenues stemming from primary facilities, services and supplies.

Input: Memo B2.3 summarizing the allocation to study sites of requirements over time for primary facilities, services and supplies.

Activities: Analyze the primary facilities, services and supplies expected to be furnished from each study site to determine the time pattern and amount of indirect land requirements by use; primary water requirements; primary tax revenues; and expenditures by relevant SIC categories.

Output:

- product B3.1 describing types of indirect land requirements and including a tabular summary of indirect land requirements by type of use over time for each affected study site;
- product B3.2 describing primary water requirements and including a tabular summary of primary water requirements over time for each study site;
- product B3.3 describing primary tax revenues over time derived in each affected study site from primary exploration activities; and
- product B3.4 describing expenditures made to relevant SIC categories over time by primary activities in each affected study site.

Use:

- product B3.1 is input to Task B4 as a partial basis for determining accumulated primary and indirect land requirements;
- product B3.2 is input to Task B9 as a partial basis for determining accumulated primary and indirect water requirements;
- product B3.3 is input to Task B8 as a partial basis for the determination of total tax revenues; and
- product B3.4 is input to Task B5 as the basis for development of the input data deck for the Input/Output model.

Task B4 - Primary and Indirect Land Requirements

Objective: To determine the land requirements generated by the primary activity; the land requirements of primary facilities, services, and supplies; and the indirect land requirements for each affected study site.

Input:
- summary by type of use and amount, of primary land requirements over time for each affected study site as contained in product B2.1, Primary Land Requirements; and
- product B3.1, Indirect Land Requirements.

Activities: Aggregation of the direct and indirect land requirements over time and by type of use and amount for each affected study site, and by areas within the study site where sub-allocations were made.

Output: Product B4.1 summarizing direct and indirect land requirements.

Use: Product B4.1 is partial input to Task E4.

Task B5 - Preparation of Data for Input/Output Model

Objective: To prepare an input data deck for use in the Input/Output model.

Input:

- product B2.2, Primary Manpower Requirements;
- product B3.4, Expenditures by Relevant SIC's; and
- Additional information on the current Texas economy and the characteristics of each affected study site necessary for operation of the Input/Output model.

Activities: Prepare the input deck.

Output: The input data deck. (For purposes of reference, the data deck will be identified as memo B5.1).

Use: The data deck (memo B5.1) is a direct input to Task B6, Input/Output Model Operation.

Task B6 - Input/Output Model Operation

Objective:
- to determine indirect tax revenues,
- to determine personal income generated,
- to determine indirect employment, and
- to determine indirect water requirements.

Input:
- the input data deck (memo B5.1), and
- the program deck for the Input/Output model

Activities:
- Operate the Input/Output model for evaluation of indirect effects in each affected study site, and
- Interpret the output.

Output: Four products:
- product B6.1, a summary of indirect water requirements over time in each affected study site;
- product B6.2, a summary of indirect tax revenues to state and local governments in each affected study site;
- product B6.3, a summary of personal income generated over time in each affected study site; and
- product B6.4, a summary of indirect employment over time in each affected study site.

Use:
- product B6.1 will be a partial input to Task B9; Primary and Indirect Water Requirements;
- product B6.2 will be a partial input to Task B8, Total Tax Revenues;
- product B6.3 will be an input to Methodology G, Social Impact Assessment; and
- product B6.4 will be a partial input to Task B7, Primary and Indirect Employment.

Task B7 - Primary and Indirect Employment

Objective: To determine the total employment requirements over time in each affected study site.

Input:
- product B2.2 describing primary personnel requirements over time for each affected study site; and
- product B6.4 describing indirect personnel requirements over time for each affected study site.

Activities: Aggregation of primary and indirect personnel requirements over time for each affected study site.

Output: Product B7.1 describing primary and indirect employment requirements over time for each affected study site.

Use: Product B7.1 is input to Task E2 as a partial basis for the determination of employment requirements over time for all phases of the OCS scenario.

Task B8 - Total Tax Revenues

Objective: To estimate the total tax revenues derived over time in each affected study site.

Input:

- product B3.3 describing primary tax revenues; and
- product B6.2 describing indirect tax revenues.

Activities: Aggregate tax revenues of each affected study site over time for local and state government.

Output:

- product B8.1 describing tax revenues over time to state government from each affected study site; and
- product B8.2 describing tax revenues over time to local governments from each affected study site.

Use:

- product B8.1 is input to Task E1 as a partial basis for determination of total tax revenues to state government over time for all phases of the OCS scenario; and
- product B8.2 is input to Task E5 as a partial basis for determination of the total tax revenues to local governments over time in each affected study site.

Task B9 - Primary and Indirect Water Requirements

Objective: To determine the total water requirements over time in each affected study site.

Input:
- product B3.2 describing the primary water requirements; and
- product B6.1 describing indirect water requirements.

Activities: Aggregate primary and indirect water requirements over time for each study site.

Output: Product B9.1 describing primary and indirect water requirements over time for each affected study site.

Use: Product B9.1 is input to Task E3 as a partial basis for determining the total primary and indirect water requirements over time for all phases of the OCS scenario.

## C. Development Methodology

The methodology utilized for assessment of the primary and indirect onshore effects of the development phase of each offshore scenario will be identical to the methodology employed for assessment of the same effects during exploration. For the sake of graphic simplicity, only the exploration methodology is shown in Figure A1. The tasks, inputs, outputs, and products will be virtually the same. Tasks, of course, will be serialized CX, and memoranda and products will be serialized CX.X.

## D. Production Methodology

The methodology utilized for assessment of the primary and indirect onshore effects of the production phase of each offshore scenario will be identical to the methodology employed for assessment of the same effects during exploration. For the sake of graphic simplicity, only the exploration methodology is shown in Figure A1. The tasks, inputs, outputs, and products will be virtually the same. Tasks, of course, will be serialized DX, and memoranda and products will be serialized DX.X.

## E. Net Onshore Effects

This methodology will be utilized to determine the net onshore effects of offshore exploration, development, and production over time in each affected study site and the state as a whole. It comprises Task E1 through E9 and results in net state economic impact and net local economic impact.

Task E1 - Aggregation of State Tax Revenues for all Phases in Each Affected Study Site

Objective: To determine total state tax revenues generated in each affected study site by the exploration, development, and production phases.

Input:

- product B8.1, State Tax Revenues generated in each affected study site by the exploration phase;
- product C8.1, State Tax Revenues generated in each affected study site by the development phase; and
- product D8.1, State Tax Revenues generated in each affected study site by the production phase.

Activities: Aggregate the state tax revenues resulting from the three phases in each affected study site.

Output: Product E1.1, Total State Tax Revenues generated in each affected study site.

Use: Product E1.1 will be a partial input to Task E9, State Economic Analysis.

Task E2 - Aggregation of Primary and Indirect Employment for All Phases in Each Affected Study Site and Analysis of Local Unemployment Pool

Objective: To determine total employment in each affected study site generated by the OCS scenario.

Input:

- product B7.1 describing primary and indirect employment over time in each affected study site resulting from the exploration phase;
- product C7.1 describing primary and indirect employment over time in each affected study site resulting from the development phase;
- product D7.1 describing primary and indirect employment over time in each affected study site resulting from the production phase;
- information on available labor in each study site and the state; and
- information on characteristics of in-migrant labor force.

Activities:

- Aggregate primary and indirect employment over time in each affected study site resulting from the three phases.
- Compare total employment requirements over time with available labor in each affected study site and the state to determine for each affected study site the time distribution of:
  -commuter employment;
  -existing resident employment; and
  -new resident employment.
- Analyze new resident employment in each affected study site to determine over time the numbers of
  -new resident population;
  -new housing units; and
  -new students.

Output:

- product E2.1 describing commuter employment over time in each affected study site;
- product E2.2 describing existing resident employment over time in each affected study site; and

- product E2.3 describing over time and for each affected study site, the new resident employment, the new population, new housing units, and new students related to the OCS off-shore scenario.

Use:

- products E2.1 and E2.2 are inputs to the social impact assessment.
- product E2.3 is input to:
  -Task E6, Identification of Significant Issues;
  -Task E7, Infrastructural Models and Cost Determination;
  -Methodology F, Environmental Impact Assessment; and
  -Methodology G, Social Impact Assessment.

Task E3 - **Aggregation of Primary and Indirect Water Requirements for all Phases**

**Objective:** To determine total primary and indirect water requirements in each affected study site generated by the OCS scenario.

**Input:**

- product B9.1 describing primary and indirect water requirements over time in each affected study site resulting from the exploration phase;
- product C9.1 describing primary and indirect water requirements over time in each affected study site resulting from the development phase; and
- product D9.1 describing primary and indirect water requirements over time in each affected study site resulting from the production phase.

Activities: Aggregate primary and indirect water requirements for all phases over time in each affected study site.

Output: Memo E3.1 describing aggregated primary and indirect water requirements over time for each affected study site.

Use: Memo E3.1 is input to Task E6 as a partial basis for determining total new infrastructural water requirements.

Task E4 - Aggregation of Primary and Indirect Land Requirements

Objective: To determine total primary and indirect land requirements in each affected study site generated by the OCS off-shore scenario.

Input:

- product B4.1 describing the time pattern of primary and indirect land requirements in each affected study site resulting from the exploration phase;
- product C4.1 describing the time pattern of primary and indirect land requirements in each affected study site resulting from the development phase; and
- product D4.1 describing the time pattern of primary and indirect land requirements in each affected study site resulting from the production phase.

Activities: Aggregate over time the primary and indirect land requirements in each affected study site.

Output: Memo E4.1 describing aggregated primary and indirect land requirements in each affected study site.

Use: Memo E4.1 is input to Task E6 as a partial basis for determining infrastructural requirements and to Methodology F, Environmental Impact Assessment Methodology.

Task E5 - Aggregation of Study Site Tax Revenues

Objective: To determine total tax revenues to local governments in each affected study site resulting from the OCS scenario.

Input:

- product B8.2 describing exploration phase local tax revenues over time in each affected study site;
- product C8.2 describing development phase local tax revenues over time in each affected study site; and
- product D8.2 describing production phase local tax revenues over time in each affected study site.

Activities: Aggregate local tax revenues over time for all phases in each affected study site.

Output: Product E5.1 describing total local tax revenues over time for each affected study site resulting from the OCS offshore scenario.

Use: Product E5.1 is input to Task E8 as a partial basis for the local economic analysis.

Task E6 - Identification of Significant Issues

Objective: To identify and evaluate requirements imposed on each affected study site by the OCS scenario.

Input:

- baseline natural resources data;
- baseline socio-economic data;
- baseline infrastructural data;
- product E2.3 describing new resident population, new housing units, and new students over time for each affected study site;
- memo E3.1 describing primary and indirect water requirements over time for each affected study site; and
- memo E4.1 describing primary and indirect land requirements over time for each affected study site.

Activities:

- Compute domestic and municipal water requirements over time for new population and combine with primary and indirect water requirements to obtain total new water requirements over time in each affected study site;
- Determine what proportion of the primary and indirect land requirements over time for each affected study site will be used for residences; and
- Compare requirements for land, water, and other resources to baseline data in order to identify any potentially critical issues.

Output:

- product E6.1 describing the requirements of each affected study site;
- memo E6.2 describing issues which require special consideration in determination of infrastructural impacts.
- memo E6.3 describing total new water and land requirements over time for each study site.

Use: product E6.1 is input to:

- Methodology F, Environment Impact Assessment; and
- Methodology G, Social Impact Assessment.

memo E6.2 is input to Task E7, Infrastructural Models and Cost Determination;

memo E6.3 is input to Task E7, Infrastructural Models and Cost Determination.

Task E7 - Infrastructural Models and Cost Determination

Objective: To determine infrastructural costs to state and local governments.

Input:

- product E2.3 describing new resident population, new housing units and new students over time for each affected study site;
- memo E6.2 describing issues which require special consideration in determination of infrastructural impacts;
- memo E6.3 describing total new water and land requirements for each affected study site;
- baseline natural resources data;
- baseline socio-economic data; and
- baseline infrastructural data.

Activities:

- Evaluate infrastructural costs to state and local governments in each affected study site using infrastructural models;
- Evaluate the infrastructural impacts, other than costs, to state and local governments associated with issues requiring special consideration;
- Aggregate costs to state government over time; and
- Aggregate costs over time to local governments in each affected study site.

Output:

- product E7.1 describing costs over time to state government resulting from the OCS scenario; and
- product E7.2 describing costs over time to local governments in each affected study site resulting from the OCS scenario.

Use:

- product E7.1 is input to Task E9, State Economic Analysis; and
- product E7.2 is input to Task E8, Local Economic Analysis.

Task E8 - Local Economic Analysis

Objective: To identify the net economic impact on local governments within each study site affected by the OCS scenario.

Input:

- product E5.1 resulting from the analysis of each affected study site and describing the total tax revenues over time to each study site as a result of the OCS scenario; and

- product E7.2 resulting from the analysis of each affected study site and describing total cost over time to each study site as a result of the OCS scenario.

Activities:

- Aggregate tax revenues to local governments from each study site analysis to obtain total tax revenues to local governments over time;

- Aggregate costs to local governments from each study site analysis to obtain total costs to local governments over time;

- Compare total local government tax revenues and costs over time for each study site; and

- Compare the present worth of total tax revenues and costs accruing to local governments during the period of analysis for each study site and for all affected study sites.

Output: Product E8.1 describing the net economic impact on local governments in each study site and for all study sites resulting from the OCS scenario.

Use: Product E8.1 is used with product E9.1, describing the net state economic impact, and with the environmental and social impact analysis (Methodologies F and G) to determine the overall impact of the OCS scenario.

Task E9 - State Economic Analysis

Objective: To identify the net economic impact on the state from the OCS scenario.

Input:

- product E1.1 resulting from the analyses of all affected study sites describing total tax revenues over time to the state resulting from the OCS scenario; and
- product E7.1 resulting from the analyses of all affected study sites describing total cost over time to the state resulting from the OCS scenario.

Activities:

- Aggregate tax revenues to the state from each study site analysis to obtain total tax revenue to the state over time;
- Aggregate costs to the state from each study site analysis to obtain total cost to the state over time;
- Compare total tax revenues and total costs to state government over time; and
- Compare the present worth of total tax revenues and costs accruing to state government over the period of analysis.

Output: Product E9.1 describing the net economic impact on the state of the OCS scenario.

Use: Product E9.1 is used with product E8.1, describing the net local economic impact, and with the environmental and social impact analyses (Methodologies F and G) to determine the overall impact of the OCS scenario.

## F. Environmental Impact Assessment Methodology

The assessment of environmental impacts resulting from the postulated OCS development scenarios will be carried out in four specific tasks including:

- Environmental Impact Matrix Development;
- General Environmental Impact Evaluation;
- Special Environmental Issue Analysis; and
- Preparation of Environmental Assessment.

## Task F1 - Environmental Impact Matrix Development

Objective: To identify the environmental effects likely to result from OCS development.

Input:
- identification of critical environmental areas along the Texas coast;
- Texas Coastal Management Program's Activity Assessment Routine;
- Procedure for Evaluating Environmental Impact, a matrix model prepared by the U.S. Geological Survey; and
- memo A3.1 describing industry practices.

Activities: Reconstruct the matrix provided in the Procedure for Evaluating Environmental Impact to:
- delete types of activities and environmental effects not expected to occur as a result of OCS development or to be considered as resulting from OCS development;
- supplement the matrix with any new activities and environmental effects expected to occur as a result of OCS development which are not presently included; and
- refine the activities and environmental effects with special reference to types of activities relevant to OCS related development and to types of effects relevant to critical environmental areas.

Output: Product F1.1, a matrix indicating the types of environmental effects likely to result from each significant type of action taken during OCS development.

Use: Product F1.1 will serve as a checklist for preparation in Task F2 of the general environmental impact evaluation, for preparation in Task F3 of the special environmental issue analysis, and for preparation in Task F4 of the Environmental Assessment.

Task F2 - General Environmental Impact Evaluation

Objective: To describe the environmental effects likely to result from OCS activities.

Input:
- product F1.1, a matrix indicating the types of environmental effects likely to result from each significant type of action taken during the OCS development;
- baseline natural resources data;
- baseline socioeconomic data;
- baseline infrastructural data; and
- product E6.1, study site requirements.

Activities: Prepare a general description for each study site affected under any OCS development scenario which:
- summarizes the existing environmental features of the study site with consideration of areas of particular concern;
- describes the relationship between OCS requirements, activities in the study site, and types of environmental effect in terms of positive or negative character of change;
- identifies the intensity of OCS activity and the magnitude of environmental changes, if any, expected to occur; and
- characterizes the importance of the principal types of environmental change, and isolates special environmental issues.

Output: Products F2.1, a description of general environmental impacts related to OCS development for each study site affected under any OCS development scenario, and including the isolation of special environmental issues.

Use: Products F2.1 will be input to Task F3, Special Environmental Issue Analysis, and to Task F4 as a partial basis for preparation of the environmental assessment of each postulated OCS development scenario.

Task F3 - Special Environmental Issue Analysis

Objective: To describe the environmental aspects of each identified special issue in more detail than provided by the general environmental impact evaluation (Task F2).

Input:
- product F1.1, a matrix indicating the types of environmental effects likely to result from each significant type of action taken during the OCS development;
- product F2.1, identifying special environmental issues;
- baseline natural resources data;
- baseline socioeconomic data; and
- baseline infrastructure data.

Activities: Prepare a description of the environmental aspects of each special issue identified for each affected study site in each OCS development scenario. The description will differ from the general environmental impact evaluation in that it will include:

- identification of any significant induced, as opposed to direct or immediate, environmental effects;
- evaluation of present areas of particular concern to determine further beneficial or adverse effect; and
- a separate evaluation of unique or sensitive environmental features.

Output: Product F3.1, a description for each postulated OCS development scenario of the environmental aspects of any special issues arising in each of the affected study sites.

Use: Products F3.1 will be input to Task F4 as a partial basis for preparation of the environmental assessment of each postulated OCS development scenario.

Task F4 - Preparation of Environmental Assessment

Objective: To prepare an environmental assessment of each postulated OCS development scenario.

Input:
- product F1.1, a matrix indicating the type of environmental effects likely to result from each significant type of action taken during OCS development.
- products F2.1 and others resulting from Task F2 which describe the general environmental effects of OCS development;
- products F3.1 and others resulting from Task F3 which describe the environmental aspects of any special issues identified for one or another of the study sites in each postulated OCS development scenario;

Activities:
- Prepare an environmental assessment of each postulated OCS development scenario. The assessment will:
  - synthesize the general environmental impact evaluations and appropriate special environmental issue analyses for each study site to describe the overall environmental effects in each affected study site; and
  - summarize principal categories of environmental affects (land use, lost habitat, and others) for total affected area.

Output: Product F4.1, describing the environmental impacts of the postulated OCS development scenario.

Use: Product F4.1 will be used as a partial basis for the identification of mitigative measures and for overall evaluation of the proposed OCS development scenarios.

## G. Social Impact Assessment Methodology

This methodology will be used to assess social impacts resulting from OCS activity scenarios and will comprise four tasks:

- Social Impact Matrix Development;
- Identification of General Social Impacts;
- Identification of Special Social Impacts; and
- Preparation of Social Impact Assessment.

Task G1 - Social Impact Matrix Development

Objective: To identify the social effects likely to result from OCS development.

Input:
- various social impact reports which detail the social impacts likely to result from assorted developments or community change; and
- memo A3.1 describing industry practices.

Activities: Construct a social impact matrix which includes the type of activities and social effects expected to occur as a result of an OCS scenario.

Output: Product G1.1, a matrix presenting the types of social effects likely to occur as a result of each significant action taken in an OCS scenario.

Use: Product G1.1 will be input to Task G2, the preparation of general social impact evaluation; to Task G3, the preparation of special social issue analysis; and to Task G4, Social Assessment.

Task G2 - General Social Impact Evaluation

Objective: To describe the general social effects likely to result from OCS activities.

Input:

- product G1.1, a matrix presenting types of social effect likely to occur as a result of OCS development;
- baseline socio-economic data;
- baseline natural resources data;
- baseline infrastructural data;
- product B6.3, C6.3, and D6.3, personal income generated by OCS exploration, development, and production in each affected study site;
- product E2.1, commuter employment;
- product E2.2, existing resident employment;
- product E2.3, new resident employment; and
- product E6.1, study site requirements

Activities: Prepare a general description for each affected study site which:

- summarizes existing social characteristics of the study site;
- describes the nature of relationships between expected activities and social effects, including positive and negative changes;
- characterizes the importance of the principal types of social change and isolates special social issues.

Output: Product G2.1, a description of general social impacts related to OCS activities for each affected study site under each OCS scenario, and including the isolation of special social issues.

Use: Product G2.1 will be partial input to Task G3, Special Social Issue Analysis, and to Task G4, Preparation of Social Impact Assessment.

Task G3 - Special Social Issue Analysis

Objective: To describe the social aspects of each identified special issue in more detail than that provided by the general social impact evalution (Task G2).

Input:

- product G1.1, a matrix presenting types of social effect likely to occur as a result of OCS development;
- product G2.1, a general social impact evaluation and isolation of special social issues;
- baseline socio-economic data;
- baseline natural resources data;
- baseline infrastructural data;
- product B6.3, C6.3, and D6.3, personal income generated by OCS exploration, development, and production in each affected study site;
- product E2.1, commuter employment;
- product E2.2, existing resident employment; and
- product E2.3, new resident employment.

Activities: Prepare a description of the social aspects of each special issue identified for each affected study site in each OCS scenario. This description will differ from the general social impact evaluation in that it will include:

- consideration of the magnitude and characteristics of requirements resulting in identification of the issue;
- consideration of the manner in which requirements will be met; and
- identification of any significant induced social effects.

Output: Product G3.1, a description of special social impacts related to OCS activities for each affected study site under each OCS scenario.

Use: Product G3.1 will be partial input to Task G4, Preparation of Social Impact Assessment.

Task G4 - Preparation of Social Assessment

Objective: To prepare a social assessment of each OCS scenario.

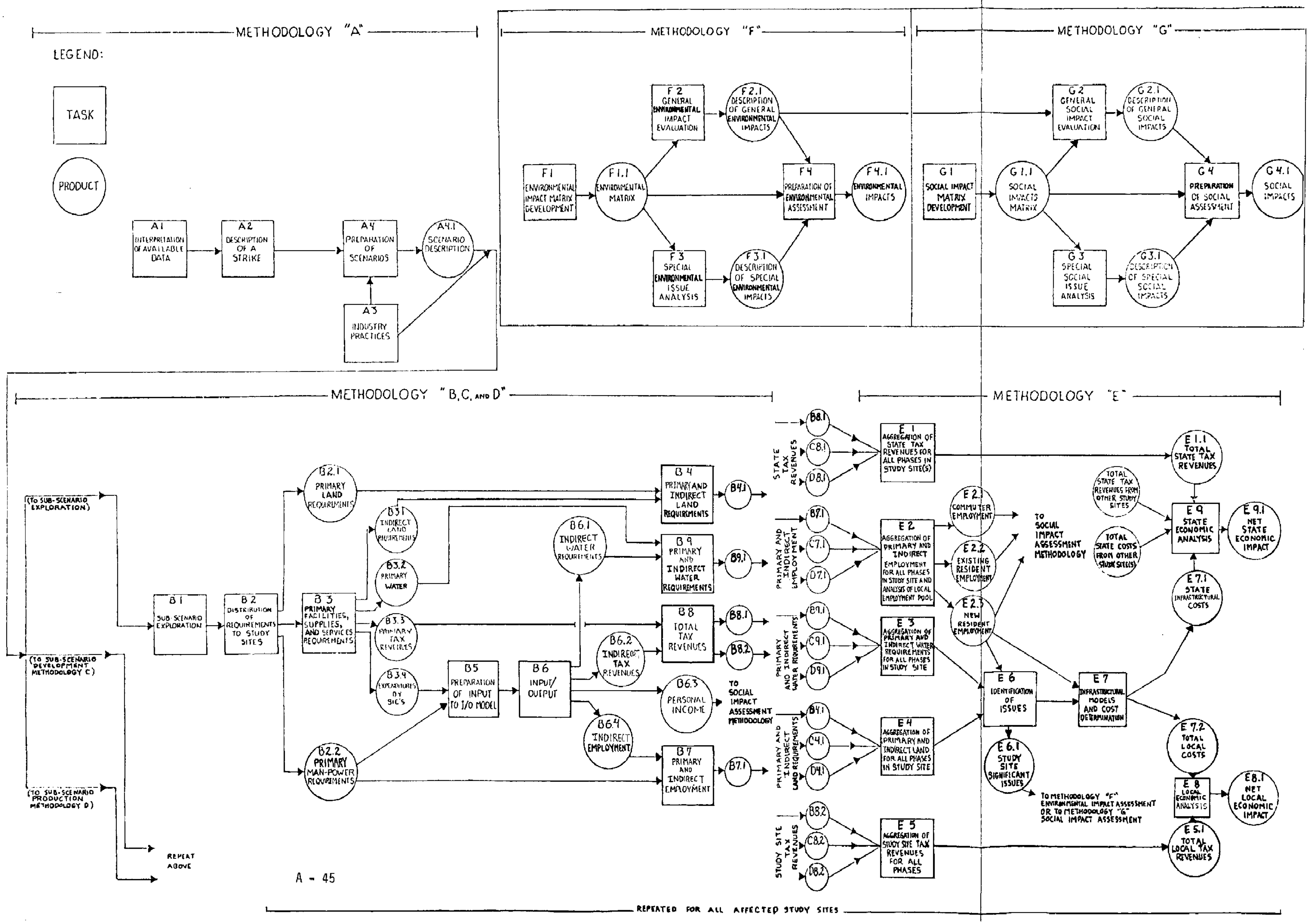
Input:
- product G1.1, a social impact matrix.
- product G2.1, describing general social impacts;
- product G3.1, describing special social impacts;

Activities:
- Prepare a description of the social effects of offshore activities associated with each OCS scenario.
- Prepare a social assessment of each OCS scenario. The assessment will:
  - synthesize the general social impact evaluations and appropriate special social impact analyses for each study site to describe the overall social effects in each affected study site; and
  - summarize principal categories of social effects (population relocation, crime and violence, and others) for the total affected area.

Output: Product G4.1, describing the social impacts of the scenario.

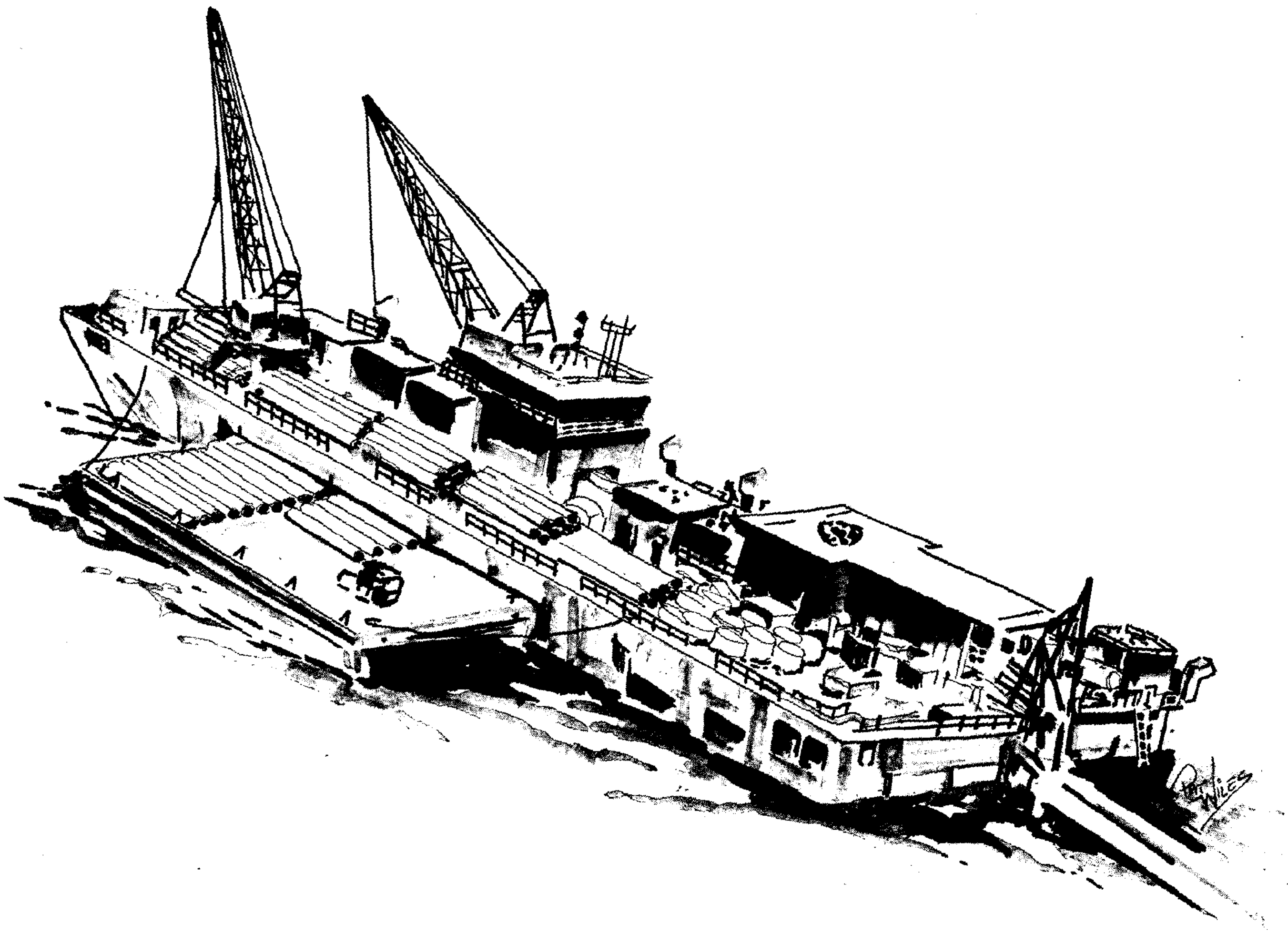
Use: Product G4.1 will be used as a partial basis for the identification of mitigative measures and for overall evaluation of the proposed scenarios.

Figure A1. ONSHORE IMPACTS OF OCS DEVELOPMENT STUDY METHODOLOGY



# APPENDIX B

## REASONABLE RANGES FOR LOCATION AND EXTENT OF OCS OIL AND GAS DEVELOPMENT IN THE TEXAS GULF OF MEXICO



## REASONABLE RANGES FOR LOCATION AND EXTENT OF OCS OIL AND GAS DEVELOPMENT IN THE TEXAS GULF OF MEXICO

In order that any study of the onshore and nearshore impacts of OCS oil and gas development may proceed, it is necessary to determine, in the form of reasonable ranges, the location, extent, and other characteristics of OCS oil and gas exploration, development, and production which may impact the area in question. In deriving those ranges for Texas, dozens of geological estimates of petroleum reserves in the Texas Gulf in addition to historical information concerning the extent and nature of Texas Gulf oil and gas development were consulted. The results of that research are presented in the following pages. Ranges are supplied for the following:

1. Tracts to be offered in each sale;
2. Tracts receiving bids;
3. Tracts leased as a percentage of tracts offered;
4. Tracts explored as a percentage of tracts leased;
5. Tracts developed as a percentage of tracts explored;
6. Tracts put into production as a percentage of tracts developed;
7. Location of tracts put into production;
8. Size of tracts put into production; and
9. Oil and gas ratio of production.

Ranges for items 1-6 were derived from past experience in the Gulf of Mexico and particularly the Texas federal OCS portion thereof. (See Figure B1.). In addition, Figure B1 illustrates acres offered, acres leased, and other past trends.

Item 7, ranges for the location of tracts to be put into production, were derived from current leasing activity in the federal OCS off Texas (see Map B1), dates and location of tracts to be offered in future sales (see Figure B2 and Map B1), geologic descriptions of the tracts (see Maps B2,B3,B4, and B5), existing and proposed pipelines (see Attachment BII), and location and extent of exploratory drilling currently underway.

Geologic data of BLM and AAPG indicate that the South Texas blocks (Mustang and Padre Island) offer oil and gas, and that the North Texas Blocks (Brazos, Galveston, and High Island) generally offer only gas. Aside from that very basic geologic data, it is virtually impossible to predict with accuracy the location of future, producing tracts. Such locations can, however, be hypothesized, with some degree of certainty (see Attachment BI). Recent leasing activity and future sales are more helpful. Recent sales have been characterized by accelerated interest in the High Island South Addition, the High Island East Addition South Extension, and the Galveston South Addition Areas. Moreover, future sales indicate interest in the same general area. Sale 44, held in October, 1976, offered

Figure B1

## Development of Reasonable Ranges of OCS Activity by Tract

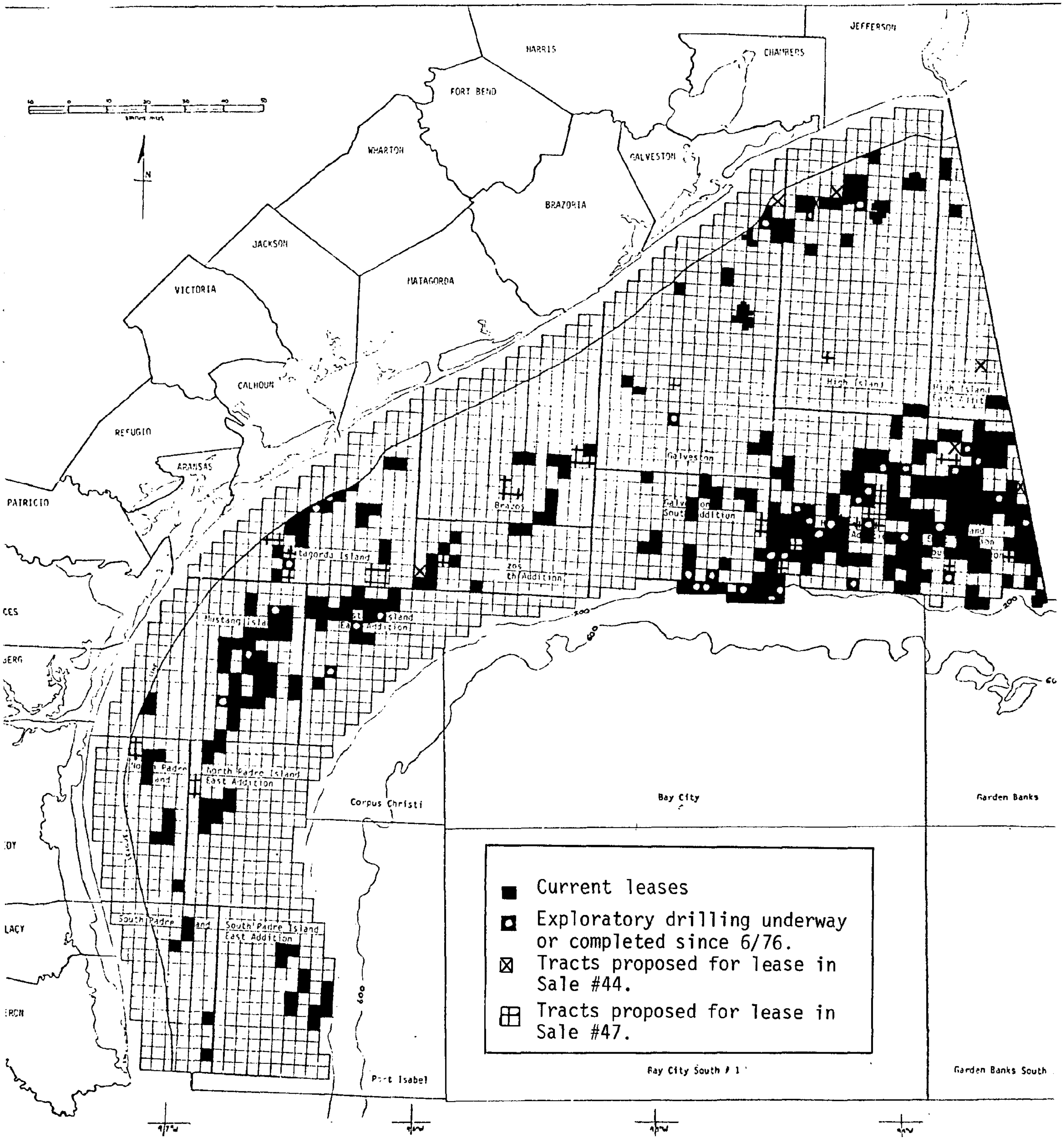
| Sale No. | Sale Date | No. Tracts Offered | % of Whole Gulf Leases in Texas | No. Tracts Receiving Bids | % Offered Tracts Receiving Bids | No. Tracts Leased | % Tracts Bidded on Actually Leased | Tracts Leased as % of Offered | No. Tracts Explored | Tracts Explored as % of Leased | No. Tracts Developed | Tracts Developed a % of Explored | No. Tracts Put Into Production | Tracts In Production as % of Developed | Acres Offered | Acres Leased | Acres Leased as % of Offered |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 11-9-54 | 38 | | 19 | 50% | 19 | 100% | 50% | 10 | 53% | 6 | 60% | 6 | 100% | 111,788 | 67,149 | 60% |
| 3 | 7-12-55 | 39 | | 27 | 69% | 27 | 100% | 69% | 3 | 11% | 0 | -- | 0 | -- | 216,000 | 149,760 | 69% |
| 7 | 2-24-60 | 97 | | 48 | 49% | 48 | 100% | 49% | 25 | 52% | 8 | 32% | 8 | 100% | 437,760 | 240,480 | 55% |
| 10 | 3-16-62 | 30 | | 10 | 33% | 10 | 100% | 33% | 2 | 20% | 0 | -- | 0 | -- | 90,720 | 28,800 | 32% |
| 22 | 5-21-68 | 169 | | 141 | 83% | 110 | 78% | 65% | 54 | 49% | 16 | 30% | 7 | 44% | 728,551 | 541,304 | 74% |
| 31 | 6-19-73 | 124 | | 104* | 81%* | *96 | 96%* | 77% | 77 | 80% | 21 | 27% | 8 | 38% | 672,643 | 527,173 | 78% |
| 34 | 5-29-74 | 245 | | 123 | 50% | 102 | 83% | 42% | 54 | 53% | 12 | 22% | 1 | 8% | 1,355,678 | 565,112 | 42% |
| 51 | 7-30-74 | 143 | | 49* | 19%* | 10 | 39%* | 7% | 1 | 10% | 0 | -- | 0 | -- | 787,821 | 53,253 | 7% |
| 37 | 2-4-75 | 515 | | 143 | 28% | 113 | 79% | 22% | 9 | 8% | 2 | 22% | 0 | -- | 2,870,344 | 626,587 | 22% |
| 38 | 5-28-75 | 36 | 13% | NA | NA | 9 | NA | 25% | -- | -- | -- | -- | - | -- | 192,660 | 51,840 | 27% |
| 38A | 7-29-75 | 176 | 51% | 80* | 23%* | 23 | 83% | 13% | -- | -- | -- | -- | - | -- | 963,832 | 132,480 | 14% |
| 41 | 2-18-76 | 30 | 23% | 13 | 43% | 12 | 92% | 40% | -- | -- | -- | -- | - | -- | 157,269 | 63,427 | 40% |
| 44 | 11-16-76 | 7 | 11% | 6 | 86% | 4 | 67% | 57% | | | | | | | 34,588 | App. 20,000 | App. 57% |
| TOTAL | | 1649 | | | | 583 | | 35% | 226++ | 54%++ | 63++ | 28%++ | 30++ | 48%++ | | | |
| ABSOLUTE RANGE | | 7-515 | | 6-143 | 19-86% | 4-113 | 39-100% | 7-77% | 1-77 | 8-80% | 0-21 | 22-60% | 0-8 | 8-100% | | | |
| EXPECTED REASONABLE RANGE (Texas only Sale) | | 50-300+ | | 15-180 | 30-60% | | | 20-50% | | 45-80% | | 30-60% | | 100% | | | |

* Louisiana and Texas data combined.
** The high end of the historic absolute range is used because data is incomplete on sales since 1973 and because this percentage appears to be increasing (see Executive Summary).
\+ For Reasonable Range of Texas leases in a whole Gulf sale: 6-66%.
++ Excludes data on activities from sales occurring since Sale 51 (7-30-74).
NA Information not available.

Source: U.S.G.S. Computer Printouts
USDI BLM Tentative Tract List for OCS Sale 44, Feb. 24, 1976
Offshore, June 20, 1976.
USDI BLM Final Environmental Statement Current Lease Status Maps (sales 34, 37, 38, 41)

MAP B1

TEXAS FEDERAL OCS



January 1977
(Revises June 1975 Schedule)

# PROPOSED OCS PLANNING SCHEDULE

| SALE AREA | 1976 J | A | S | O | N | D | 1977 J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 Gulf of Mexico | | F | | N | S | | | | | | | | | | | | | |
| CI Cook Inlet | | P | | | F | | N | S | | | | | | | | | | |
| 47 Gulf of Mexico | | | | | E | P | | F | N | S | | | | | | | | |
| 42 North Atlantic | | | | E | | P | | | F | | N | S | | | | | | |
| 43 South Atlantic | | | | | | | | E | | P | | F | | N | S | | | |
| 46 Kodiak | | | | | | | | | E | | P | | | F | | N | S | |
| 45 Gulf of Mexico | | | | | | | T | | | E | | P | | | F | | N | S |
| 48 Southern California | C | | D | | | | T | | | | | | E | | P | | | F |
| 49 Mid-Atlantic | | | | | C | | D | | | T | | | | | | E | | P |
| Beaufort Sea (near shore) | | | | | | | | | State - Federal Sale | | | | | | | | | |
| 51 Gulf of Mexico | | | | | | | C | | D | | | T | | | | | | E |
| 53 General Pacific | | | | | | | C | | D | | | | | T | | | | |
| 54 S. Atlantic Blake Plateau | | | | | | | | | | | C | | D | | | T | | |
| 50 Beaufort Sea 2/ | | | | | | | | | | | | | C | | D | | | T |
| 55 Northern Gulf of Alaska | | | | | | | | | | | | | | | | C | | D |
| 52 North Atlantic | | | | | | | | | | | | | | | | | C | |
| 56 South Atlantic | | | | | | | | | | | | | | | | | | |
| 58 Gulf of Mexico | | | | | | | | | | | | | | | | | | |
| 57 Bering - Norton | | | | | | | | | | | | | | | | | | |
| 59 Mid-Atlantic | | | | | | | | | | | | | | | | | | |
| 60 Bering Sea St George | | | | | | | | | | | | | | | | | | |
| 61 Cook Inlet | | | | | | | | | | | | | | | | | | |
| 62 Gulf of Mexico | | | | | | | | | | | | | | | | | | |
| 63 General Pacific | | | | | | | | | | | | | | | | | | |
| 64 Kodiak - Aleutian | | | | | | | | | | | | | | | | | | |

| SALE AREA | 1978 J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 Gulf of Mexico | | | | | | | | | | | | |
| CI Cook Inlet | | | | | | | | | | | | |
| 47 Gulf of Mexico | | | | | | | | | | | | |
| 42 North Atlantic | | | | | | | | | | | | |
| 43 South Atlantic | | | | | | | | | | | | |
| 46 Kodiak | | | | | | | | | | | | |
| 45 Gulf of Mexico | | | | | | | | | | | | |
| 48 Southern California | | N | S | | | | | | | | | |
| 49 Mid-Atlantic | | | F | | N | S | | | | | | |
| Beaufort Sea (near shore) | | 1/ | | | | | | | | | | |
| 51 Gulf of Mexico | | P | | | F | | N | S | | | | |
| 53 General Pacific | | E | | P | | | F | | N | S | | |
| 54 S. Atlantic Blake Plateau | | | | E | | P | | | F | | N | S |
| 50 Beaufort Sea 2/ | | | | | | E | | P | | | F | |
| 55 Northern Gulf of Alaska | | | T | | | | | | E | | P | |
| 52 North Atlantic | D | | | T | | | | | | E | | P |
| 56 South Atlantic | | C | | D | | | T | | | | | |
| 58 Gulf of Mexico | | | C | | D | | | T | | | | |
| 57 Bering - Norton | | | | | C | | D | | | T | | |
| 59 Mid-Atlantic | | | | | | | | C | | D | | |
| 60 Bering Sea St George | | | | | | | | | | C | | D |
| 61 Cook Inlet | | | | | | | | | | | | |
| 62 Gulf of Mexico | | | | | | | | | | | | |
| 63 General Pacific | | | | | | | | | | | | |
| 64 Kodiak - Aleutian | | | | | | | | | | | | |

| SALE AREA | 1979 J | F | M | A | M | J | J | A | S | O | N | D | 1980 J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 Gulf of Mexico | | | | | | | | | | | | | | | | | | | | | | | | |
| CI Cook Inlet | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 Gulf of Mexico | | | | | | | | | | | | | | | | | | | | | | | | |
| 42 North Atlantic | | | | | | | | | | | | | | | | | | | | | | | | |
| 43 South Atlantic | | | | | | | | | | | | | | | | | | | | | | | | |
| 46 Kodiak | | | | | | | | | | | | | | | | | | | | | | | | |
| 45 Gulf of Mexico | | | | | | | | | | | | | | | | | | | | | | | | |
| 48 Southern California | | | | | | | | | | | | | | | | | | | | | | | | |
| 49 Mid-Atlantic | | | | | | | | | | | | | | | | | | | | | | | | |
| Beaufort Sea (near shore) | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 Gulf of Mexico | | | | | | | | | | | | | | | | | | | | | | | | |
| 53 General Pacific | | | | | | | | | | | | | | | | | | | | | | | | |
| 54 S. Atlantic Blake Plateau | | | | | | | | | | | | | | | | | | | | | | | | |
| 50 Beaufort Sea 2/ | N | S | | | | | | | | | | | | | | | | | | | | | | |
| 55 Northern Gulf of Alaska | | F | | N | S | | | | | | | | | | | | | | | | | | | |
| 52 North Atlantic | | | F | | N | S | | | | | | | | | | | | | | | | | | |
| 56 South Atlantic | E | | P | | | F | | N | S | | | | | | | | | | | | | | | |
| 58 Gulf of Mexico | | E | | P | | | F | | N | S | | | | | | | | | | | | | | |
| 57 Bering - Norton | | | | E | | P | | | F | | N | S | | | | | | | | | | | | |
| 59 Mid-Atlantic | T | | | | | | E | | P | | | F | | N | S | | | | | | | | | |
| 60 Bering Sea St George | | | T | | | | | | E | | P | | | F | | N | S | | | | | | | |
| 61 Cook Inlet | C | | D | | | T | | | | | | E | | P | | | F | | N | S | | | | |
| 62 Gulf of Mexico | | C | | D | | | T | | | | | | E | | P | | | F | | N | S | | | |
| 63 General Pacific | | | | C | | D | | | T | | | | | | E | | P | | | F | | N | S | |
| 64 Kodiak - Aleutian | | | | | C | | D | | | T | | | | | | E | | P | | | F | | N | S |

Director, Bureau of Land Management

C - Call for Nominations
D - Nominations Due
T - Announcement of Tracts
E - Draft Environmental statement
P - Public Hearing
F - Final Environmental Statement
N - Notice of Sale
S - Sale

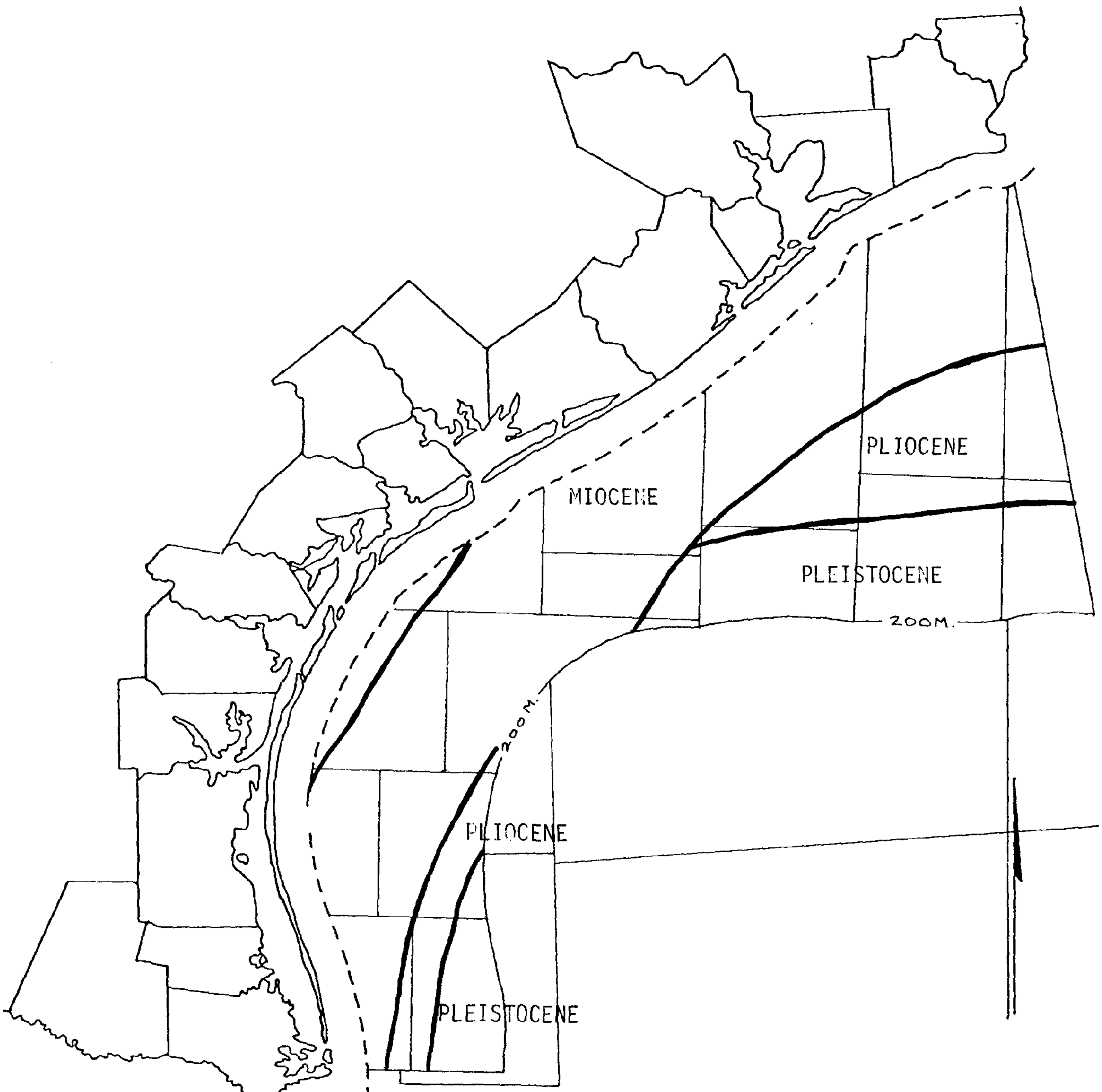
1/ State May Conduct Sale
2/ Within 60 Foot Isobath or Technology Capability

Sales are contingent upon technology being available for exploration and development. A decision whether to hold any of the lease sales listed will not be made until completion of all necessary studies of the environmental impact and the holding of public hearings; as a result of the environmental, technical, and economic studies employed in the decision making process, a decision may, in fact, be made not to hold any sale on this schedule.

Figure B2

MAP B2

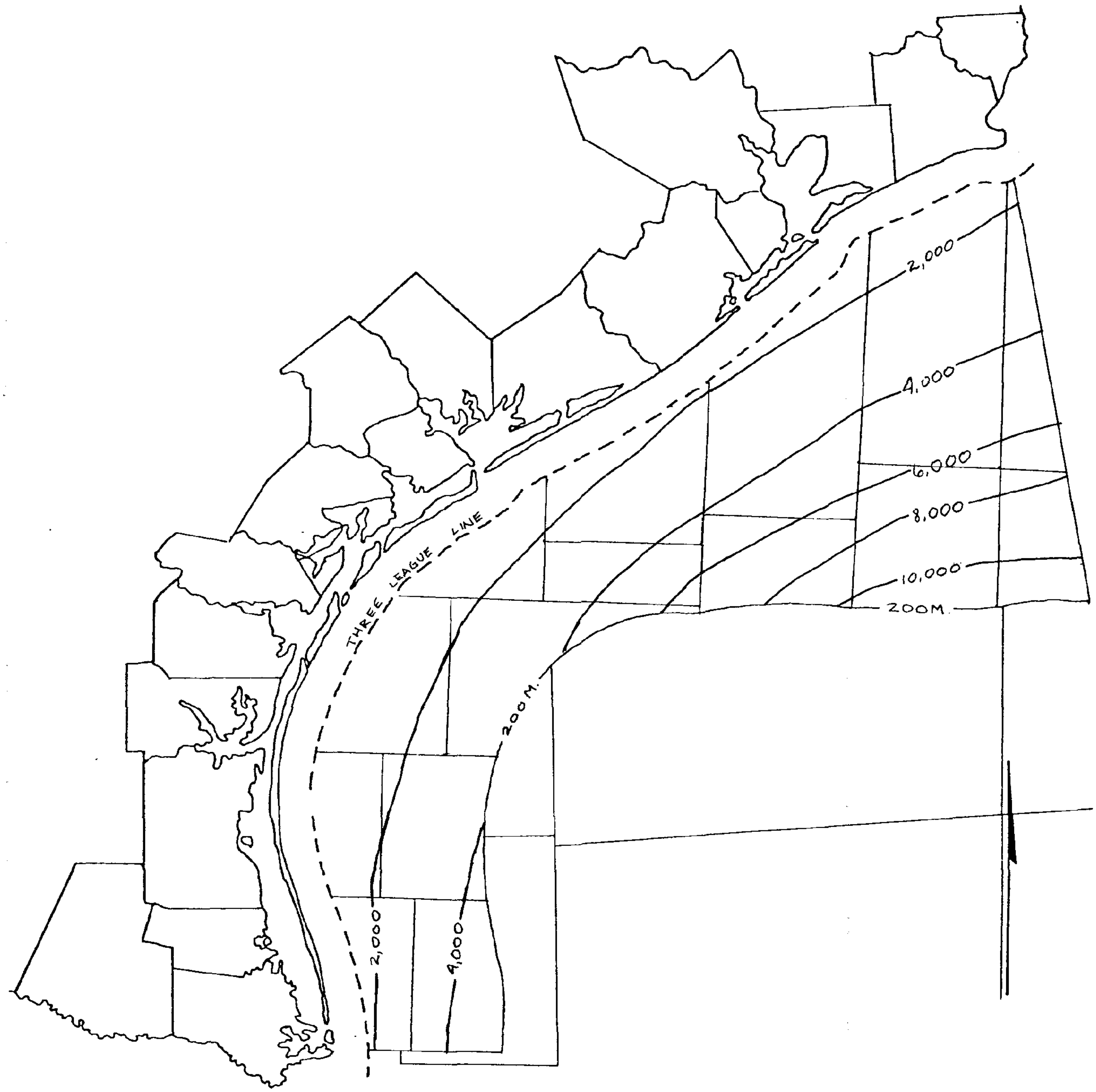
PETROLEUM-DRILLING TREND




(Areas in OCS where drilling usually occurs to producing stratigraphic unit. Boundary lines at 4,000 to 8,000 foot depth.)

MAP B3

PLEISTOCENE

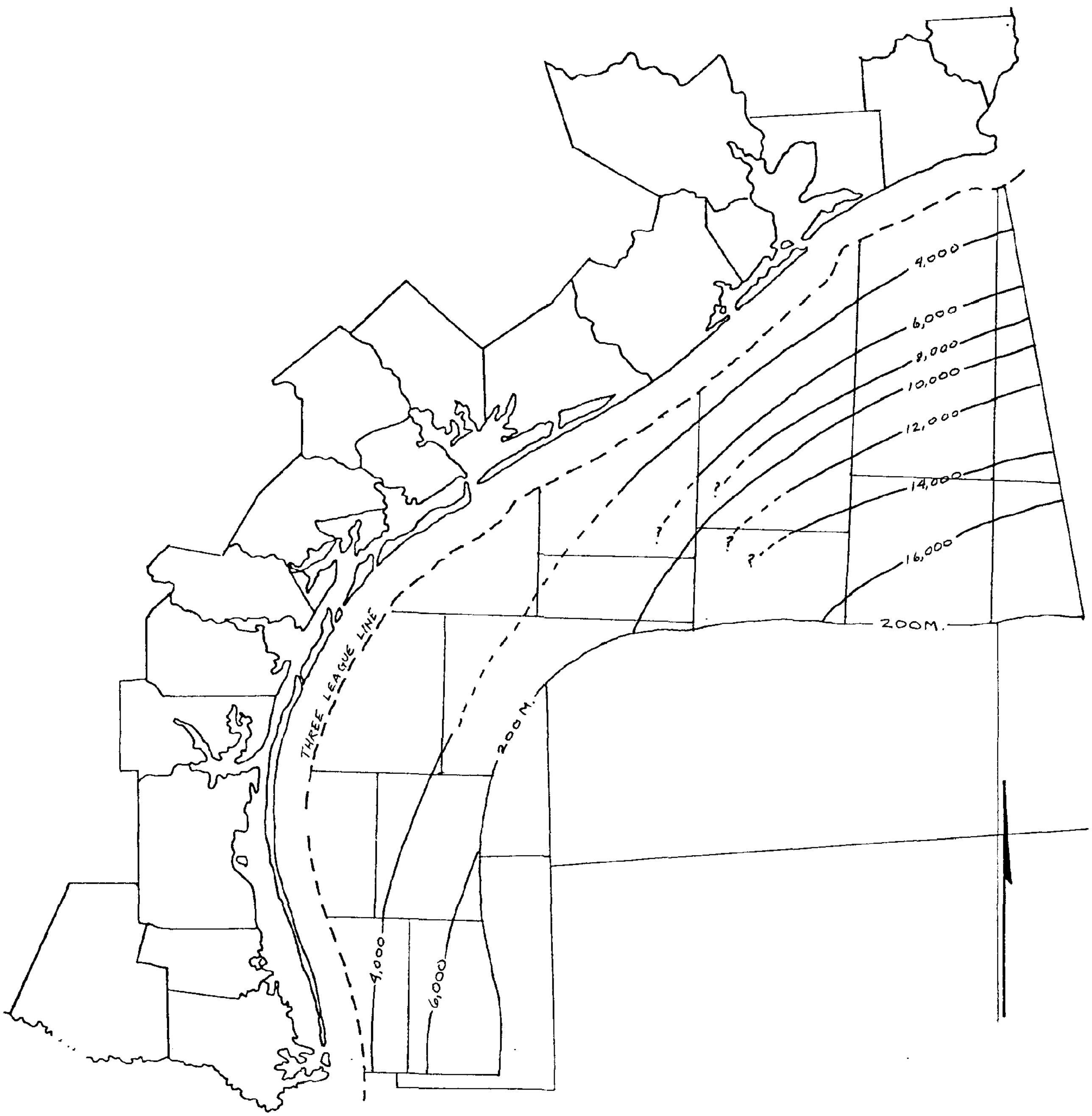



Contour map of Pleistocene trend. Depth (approximate) in feet.

(Source of Maps B3, B4, and B5 in A.A.P.G. Memoir 15(2). 1971)

MAP B4

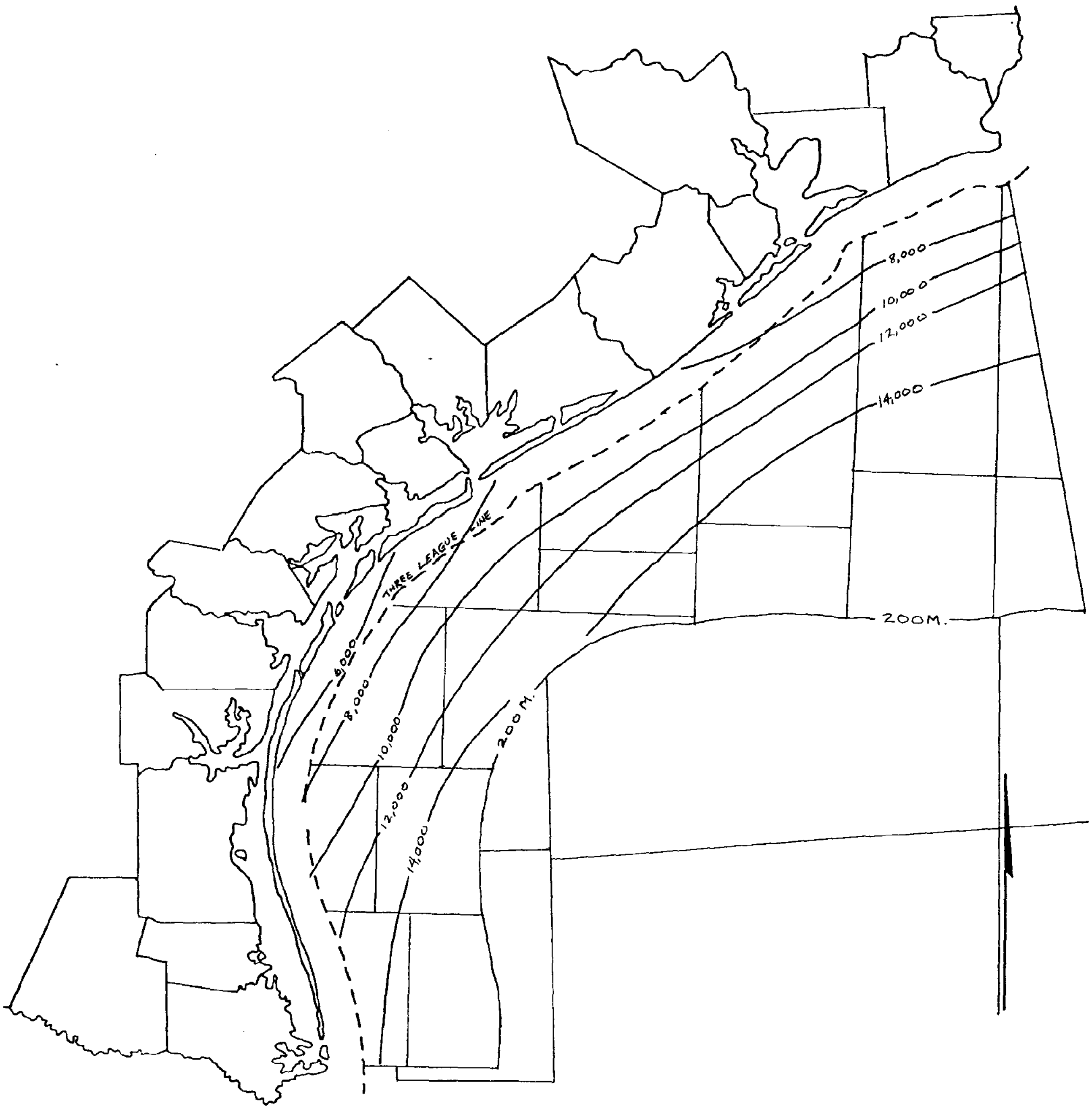
PLIOCENE




Contour map of bottom of Pliocene trend. Top of Pliocene shown in Map B3. Depth (approximate) in feet.

MAP B5

MIOCENE




Contour map of bottom of Miocene trend. Top of Miocene (approximate) in feet.

61 tracts; 7 are located in the federal OCS off Texas. Of those 7, 1 was in the Matagorda Area, 3 in the High Island Area at the 3-league line, 1 in the High Island East Addition Area, and 2 in the High Island East Addition South Extension Area (see Map B1). Sale 47, to be held in April, 1977, will offer, in addition to other tracts, tracts on the continental slope to a depth of 600 meters. To date, a total of 13 tracts have been leased in the "deep" Texas federal OCS; they are all adjacent to the Galveston South Addition or High Island South Addition Areas. Sale 45, scheduled for December, 1977, also tentatively offers tracts in the areas referred to above, in addition to other areas.

Pipeline activity in the Texas Gulf of Mexico is composed of pipelines which have already been constructed to service existing, producing tracts (see Attachment BII), or proposed pipelines. In terms of existing pipelines, it is reasonable to assume the producers may be drawn to areas which are currently served by pipelines since significant transportation costs could thus be minimized. Attachment BII illustrates that all recent proposals for pipeline activity in the Texas Gulf were for lines designed to serve the High Island, High Island South Addition, High Island East Addition, or High Island East Addition South Extension Areas.

Finally, the location and extent of exploratory drilling in the Texas federal OCS is also telling. In June, 1976, for example, 11 exploratory wells were being drilled in the federal OCS off Texas; 1 in the Galveston South Addition Area, one in the Matagorda Island Area, one in the Mustang Island East Addition Area, two adjacent to the High Island South Addition Area three in the High Island South Addition Area, one in the High Island Area, and two in the High Island East Addition South Extension Area. (see Map B1). Exploratory drilling since that time has followed a similar pattern.

Thus, when all the data is compiled, it is reasonable to infer the following ranges for locations of future strikes (not necessarily in order of likelihood):

1. High Island East Addition South Extension Area;
2. High Island South Addition Area;
3. Bay City Area, adjacent to the 200-meter line;
4. Matagorda Island Area;
5. Brazos South Addition Area;
6. Galveston South Addition Area;
7. South Padre Island East Addition Area;
8. Mustang Island Area;
9. Mustang Island East Addition Area; and
10. South Padre Island Area.

(see also Attachment BI.)

Ranges for item 8, size of tracts to be put into production at some future date, were derived from estimates of total recoverable reserves of oil and gas in the federal OCS off Texas and from present trends of production in that region.

Estimates of recoverable reserves vary widely (see Figure B3). Reserve estimates are further complicated by the fact that some include the entire Gulf of Mexico and some provide estimates for sections of the Gulf. The best estimates of total reserves available in the Texas portion of the Gulf of Mexico are derived by multiplying a reasonable range of entire Gulf of Mexico estimates by Texas' historical share of Gulf of Mexico production.

Figure B3 provides a range for total Gulf of Mexico oil reserves of 10.9 - 69 billion BBLs; the range for gas is 152 - 384.3 trillion cubic feet. Those figures must be considered with the fact that Texas has historically accounted for between .4% and .7% of total Gulf oil and condensate and for between 4.4% and 5.5% of total Gulf gas.

Those two sets of statistics taken together provide the following ranges of total oil and gas production potential in the Texas portion of the Gulf of Mexico:

| | |
|---|---|
| Oil and Condensate: | .04 to .46 billion BBLs |
| Gas: | 6.68 to 21.14 trillion cubic feet. |

Production by tract in the Texas portion of the OCS for the past three years indicates that annual oil production ranges from 24,294 to 620,321 barrels per tract, and that annual gas production ranges from 34,000 MCF to 54,730,000 MCF per tract. Reasonable ranges for an active producing tract are:

Oil: 95,000 to 600,000 barrels annually
Gas: 14,000,000 MCF to 32,000,000 MCF annually

Item 9, ranges for the oil/gas ratio, were computed for the entire Texas federal OCS and for individual tracts. Texas Railroad Commission statistics indicate that production in the federal OCS off Texas in recent years has been at a 1/153 to 1/329 barrel of oil to MCF gas ratio (see Figure B4). Production by tract in the Texas federal OCS has been at a 1/29 to 1/530 oil to gas ratio. A reasonable range for oil to gas ratio in an active production tract in the Texas Gulf is a 1/150 to 1/300 barrel of oil to MCF gas ratio. It is important to note, however, that such a ratio is largely dependent on location of the tract. Some will offer virtually no oil.

In addition to providing reasonable ranges for the foregoing nine items, a description of the assumptions concerning overall energy supply, international pricing, and other matters affecting the timing and manner of exploration, development, and production in the Texas federal OCS is essential to the analysis of onshore impacts of OCS oil and gas production.

Figure B3

RESERVE ESTIMATES

| Source | Location | Oil (Billion Barrles) | Gas (Trillion cu. ft.) |
|---|---|---|---|
| BLM OCS Sale 37 | Texas | .2 - .6 | 4 - 12 |
| Offshore 33:60 (April '73) | Texas | .1 | 2.5 |
| U.S. Energy Outlook (Dec. '72) | Gulf of Mexico | 27.1 | 156.4 |
| Kash (reports of U.S.G.S.)* | Gulf of Mexico | 69 (OCS); 53(slope) | 300(OCS); 236(slope) |
| U.S.G.S. '75 | Gulf of Mexico | | |
| | measured | 2.2 | 35.3 |
| | indicated | .05 | - |
| | inferred | 2.4 | 67.0 |
| | undiscovered recoverable resource | 3 - 8 | 18 - 91 |
| | (natural gas liquids) | 1.3 | N.A. |
| | TOTALS | 10.9 | 152 |
| USDI Energy Perspective | Gulf of Mexico | | |
| | measured | 4.0** | 43.3 |
| | indicated & inferred | 2.0-3.5** | 21-41 |
| | undiscovered recoverable resource | 20-40** | 160-320 |
| | TOTALS | 26-47.5 | 224-384.3 |

* ultimate production

** crude oil plus natural gas liquids

Figure B4

PRESENT TRENDS IN PRODUCTION - FEDERAL TEXAS OCS

| | Gas and Casinghead Gas MCF | Oil and Condensate Barrels | Gas/Oil Mcf/Bbls |
|---|---|---|---|
| 1975 | 101,434,765 | 426,508 | 239 |
| 1974 | 141,338,180 | 493,602 | 286 |
| 1973 | 124,219,217 | 727,983 | 170 |
| | | | |
| 1-1976 | 8,250,062 | 34,265 | 241 |
| 1-1975 | 8,995,091 | 37,017 | 243 |
| 1-1974 | 14,487,351 | 43,977 | 329 |
| 1-1973 | 10,538,122 | 68,836 | 153 |
| 1-1972 | 12,088,698 | 68,008 | 178 |

Source: TRC Offshore Production Files

PRODUCTION PER ACRE

| | GAS (MCF/ACRE) | OIL AND CONDENSATE (BBLS/ACRE) |
|---|---|---|
| 1974 | 858 | 7 |
| 1973 | 850 | 9 |
| 1972 | 885 | 10 |
| 1971 | 870 | 12 |
| 1970 | 911 | 15 |
| 1969 | 1,523 | 33 |
| 1968 | 9,620 | 272 |
| 1967 | 2,644 | 76 |

Source: USGS *OCS Statistics*

The rate at which OCS tracts are nominated, offered, leased, explored, and developed is profoundly affected by the composite energy supply/demand situation existing in the United States. Assumptions regarding the rate at which OCS development will proceed in future years must be predicated on past and current supply and demand trends as well as projected trends.

What has come to be known as the "energy crisis" can be simply defined as a growing disparity between supply of energy and energy availability. This disparity is especially evident with regard to petroleum and natural gas. Figure B5 illustrates that U.S. gross energy consumption rose from 44.6 quadrillion BTUs in 1960 to 73.2 quadrillion BTUs in 1974: an increase of 64%. During the same period, consumption of petroleum rose from 45% to 46% of the total consumption; consumption of gas rose from 28% to 30%.

Figure B6 details U.S. energy production and consumption for 1973 and 1974. While consumption declined slightly, U.S. production declined also; the total difference between production and consumption in 1974 was still 12.5 quadrillion BTUs. Most of that disparity was accounted for by the difference between petroleum production and consumption: 13.1 quadrillion BTUs; the difference for natural gas was .7 quadrillion BTUs. (The overall disparity was less severe due to the fact that coal production exceeded consumption by 1.4 quadrillion BTUs.)

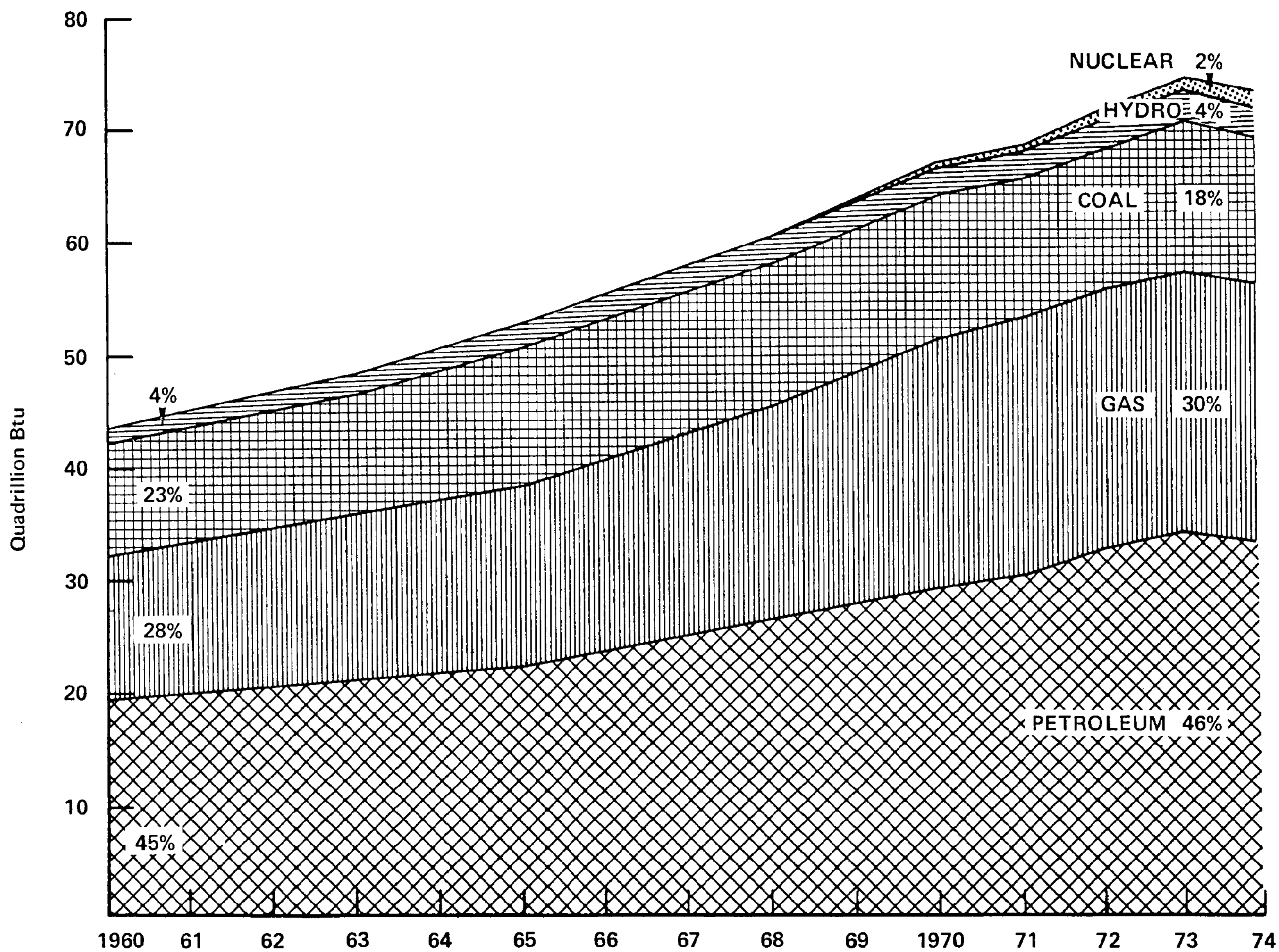
Projections indicate that consumption will not continue to decline but will, in fact, rise over the long term. Figure B7 shows a 58% increase in consumption between 1973 and 1990, even assuming an effective conservation program. (Figure B7 assumes Business as Usual and oil priced at $7 per barrel.) The consumption of petroleum is projected to rise by 14.1%, assuming an accelerated nuclear power production effort. Natural gas consumption is projected to climb by 13.6%.

The supply and production side of the equation gives cause for concern. U.S. petroleum supply declined from 1973 to 1974 (see Figure B8), but of more importance is the steady decline of U.S. domestic production as a percentage of total supply since 1960 and in absolute quantity since 1970 (except for a slight increase in 1972). Imported petroleum, on the other hand, has risen dramatically. In 1960, imported crude petroleum and petroleum products accounted for 17% of total U.S. petroleum supply; in 1974 they accounted for 36%.

That portion of U.S. petroleum supply which was produced domestically in 1974 can be broken into onshore production and federal OCS production (see Figure B9). Production of both has declined in recent years: onshore production from a high of 3737.1 million barrels in 1970 to 3425.8 in 1974, and federal OCS production from a high of 455.4 million barrels in 1971 to 424.2 in 1974. The percentage of U.S. petroleum production which is supplied from the federal OCS rose from 2% in 1961 to 11% in 1970 and has remained relatively constant since.

Figure B5

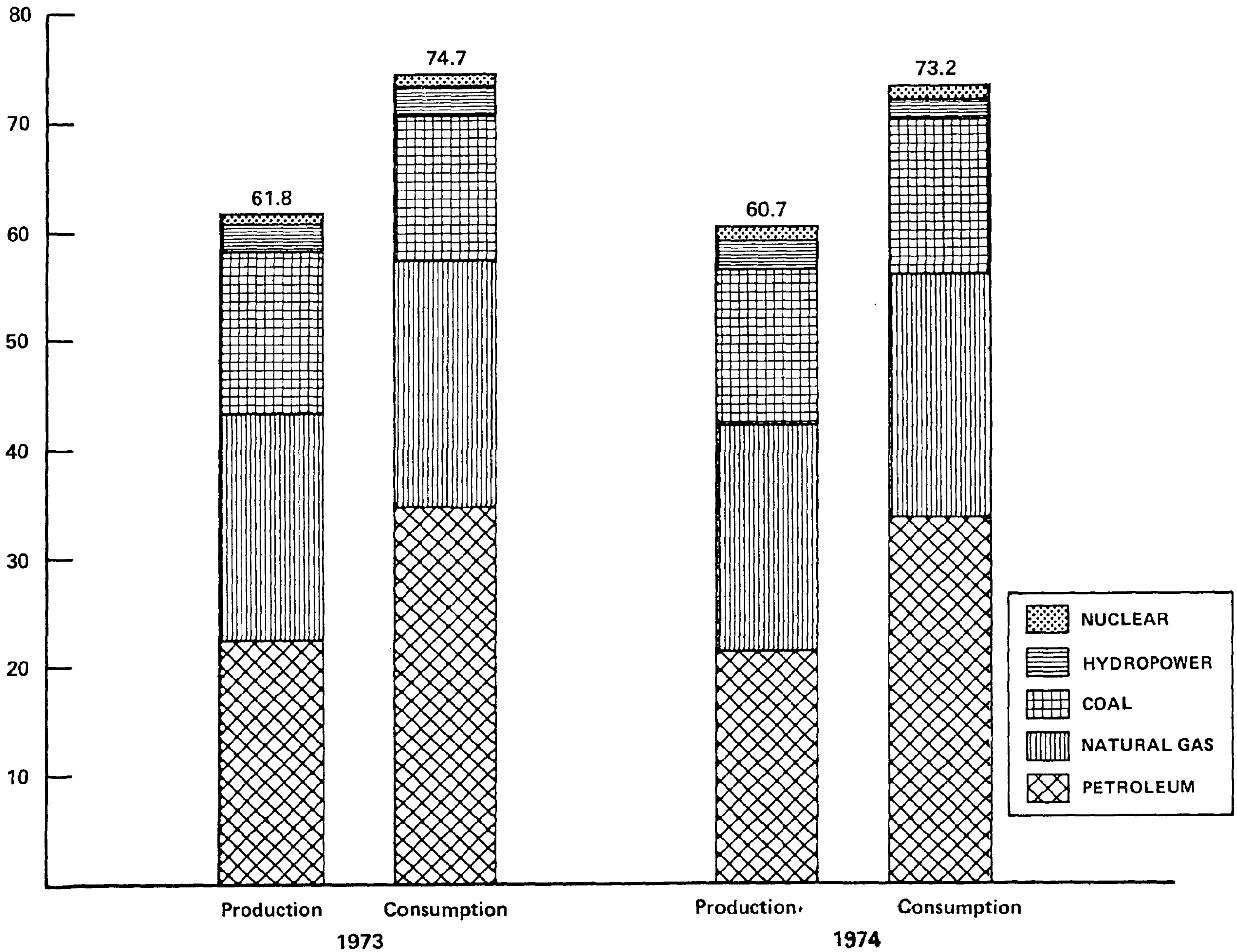
# U.S. Gross Energy Consumption Patterns By Source, 1960-74




SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

Figure B6

# U.S. Energy Production and Gross Consumption, 1973 and 1974

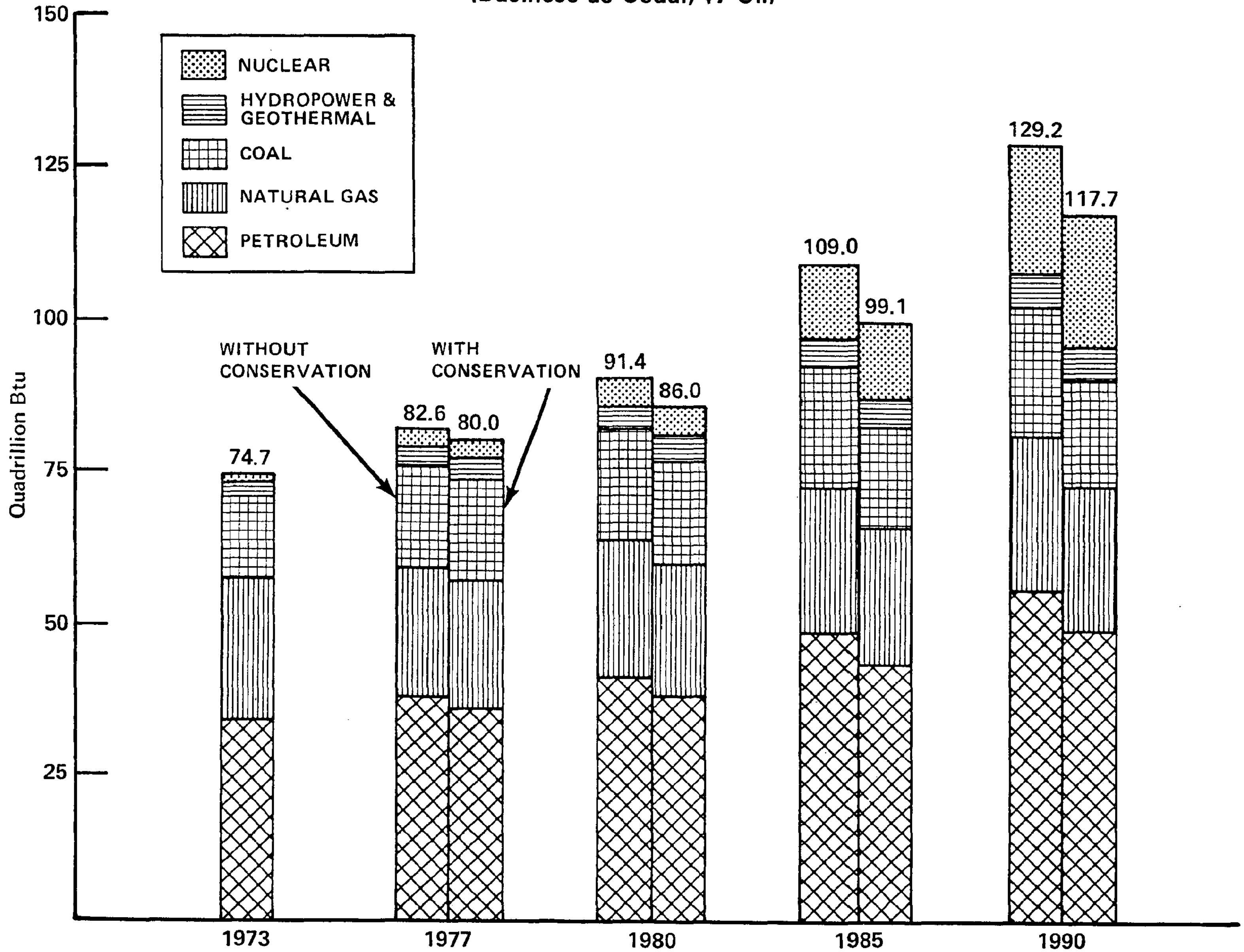



SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

Figure B7

## U.S. Gross Energy Consumption, 1973-90

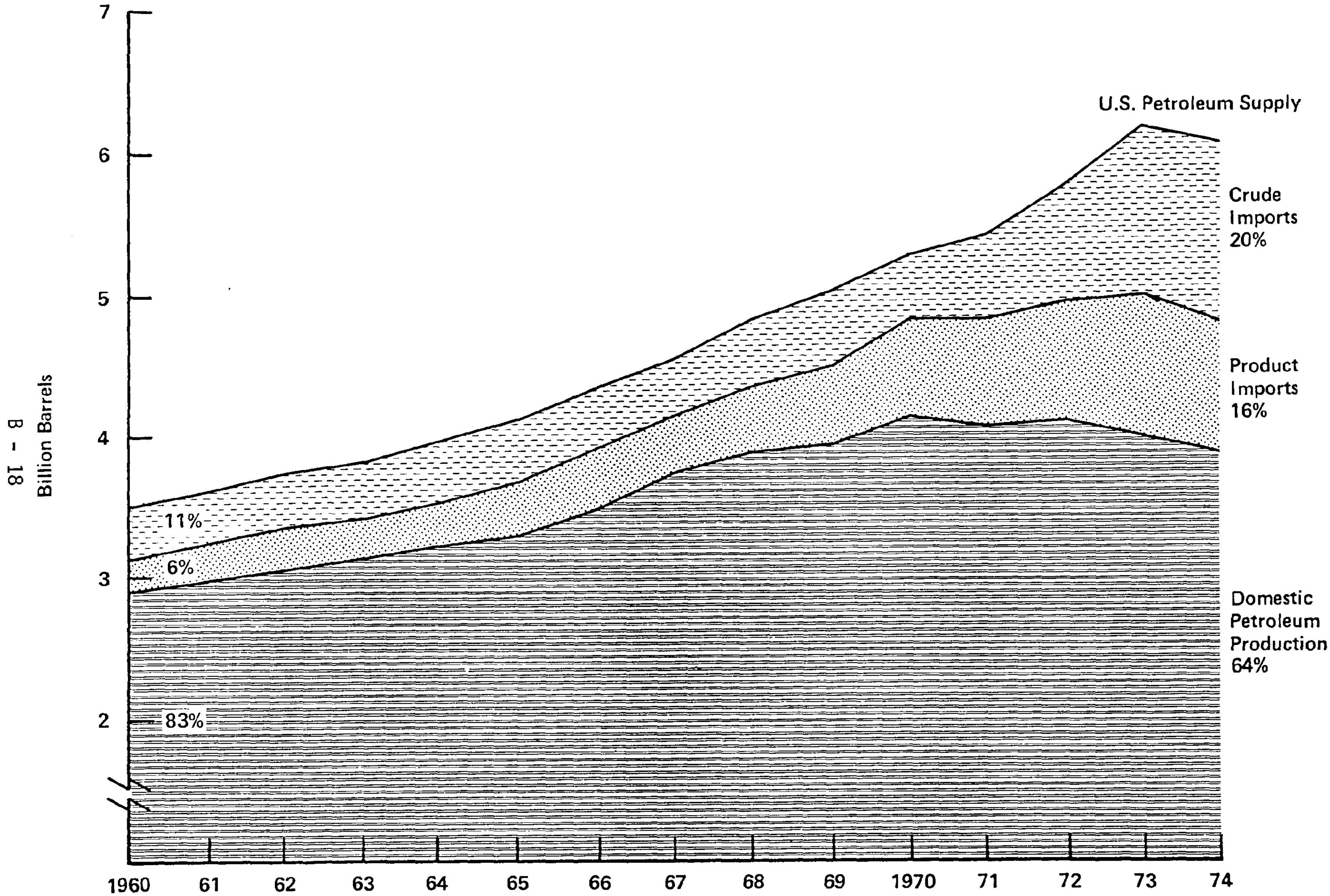
**(Business as Usual, $7 Oil)**




SOURCES: Energy Perspectives, U.S. Dept. of Interior, 1975.

Figure B8

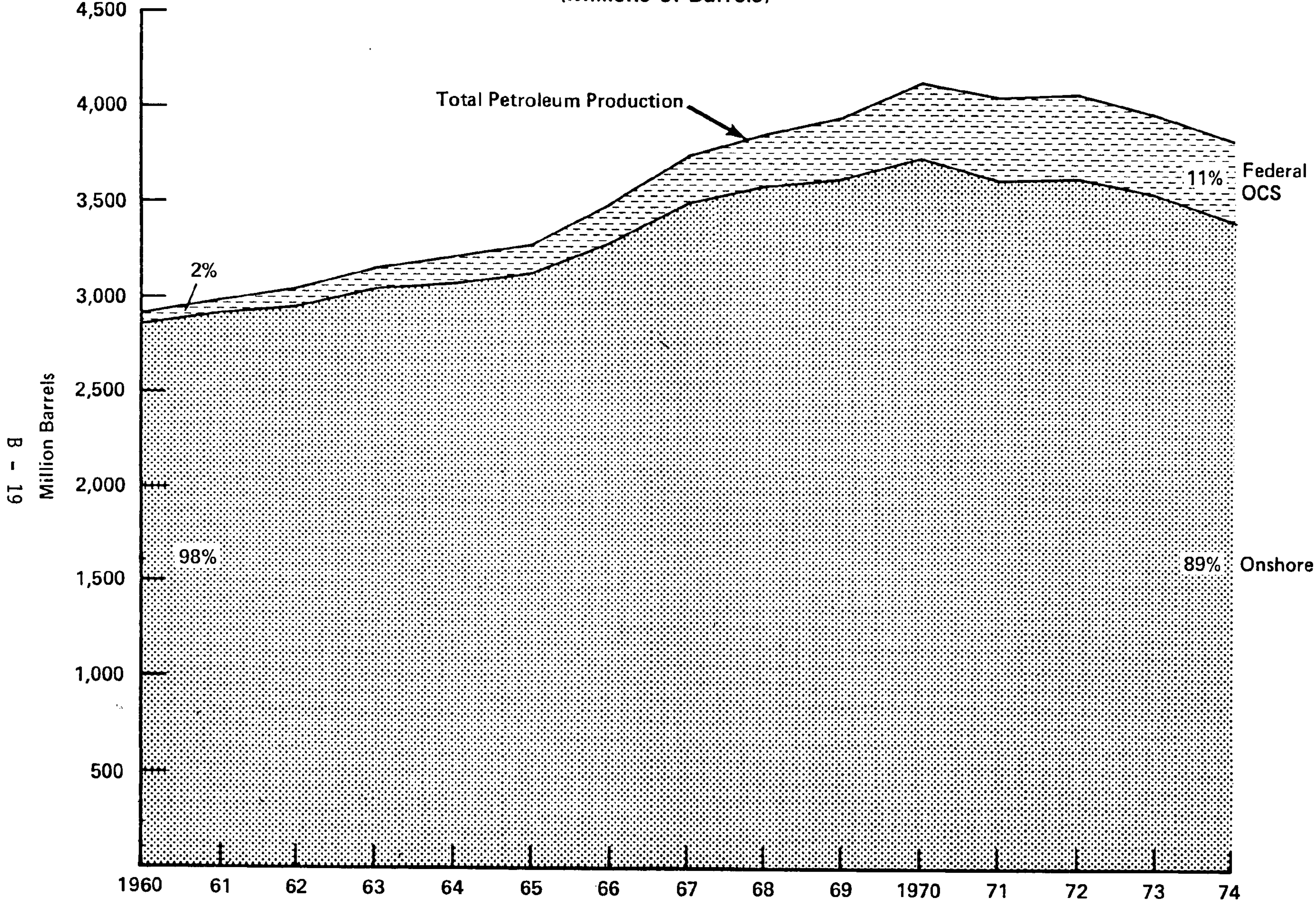
## U.S. Petroleum Supply, 1960-74




SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

# U.S. Petroleum Production, 1960-74

(Millions of Barrels)




SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

While the recent history of natural gas supply and demand has not been as concerning as that of petroleum, domestic production has fallen and imports have increased (see Figure B10). Total supply fell from a high of 23.61 trillion cubic feet in 1973 to 21.8 in 1974. Domestic production climbed steadily to a high of 22.65 trillion cubic feet in 1973, then fell to 20.8 in 1974. At the same time, imports rose to .96 in 1973, then declined slightly to .94 in 1974. Imported natural gas as a percentage of total supply, however, has not declined; it rose from 1.1% in 1960 to 2.6% in 1965,3.3% in 1970, 4.1% in 1973, and 4.3% in 1974.

Natural gas production from the federal OCS, on the other hand, has risen sharply in recent years: from 273 billion cubic feet in 1960 to 3553.4 billion cubic feet in 1974 (see Figure B11). Since 1970, annual production increases have been 14.1% (1970-71), 9.4% (1971-72), 5.7% (1972-73), and 10.6% (1973-74).

Thus, the petroleum and natural gas prospects include increasing consumption, declining overall domestic production, and increasing reliance on imports. But these trends are not totally the result of decreasing availability of energy resources. Indeed, some estimates predict that the nation's known reserves of fuel minerals will last 190 years at 1970 consumption rates and that potential resources of fuel minerals could last 16,500 years at 1970 consumption rates. If those projections are accurate, lack of recovery, not lack of availability, underlies the "crisis".

It is true that the number of exploratory wells has declined from 1955 through 1971: from 14,937 to 6,922, a drop of 54% (see Figure B12). The number rose from 1971 to 1973, however, by 7.8%. Oil and gas wells drilled in the U.S. fell sharply from 1965 to 1973, but then rose again (see Figure B13), to 31,813, a 15.5% increase.

For purposes of RPC's study of near shore and onshore impacts of OCS oil and gas development, straight line projections of present trends and "business as usual" assumptions will, for the most part, be used. These assumptions include:

1. Business as usual; that is, existing policies continue and only incremental, limited policy changes are considered; a constant price of $11 per barrel of petroleum; and a ceiling price of 50 cents per thousand cubic feet of natural gas.

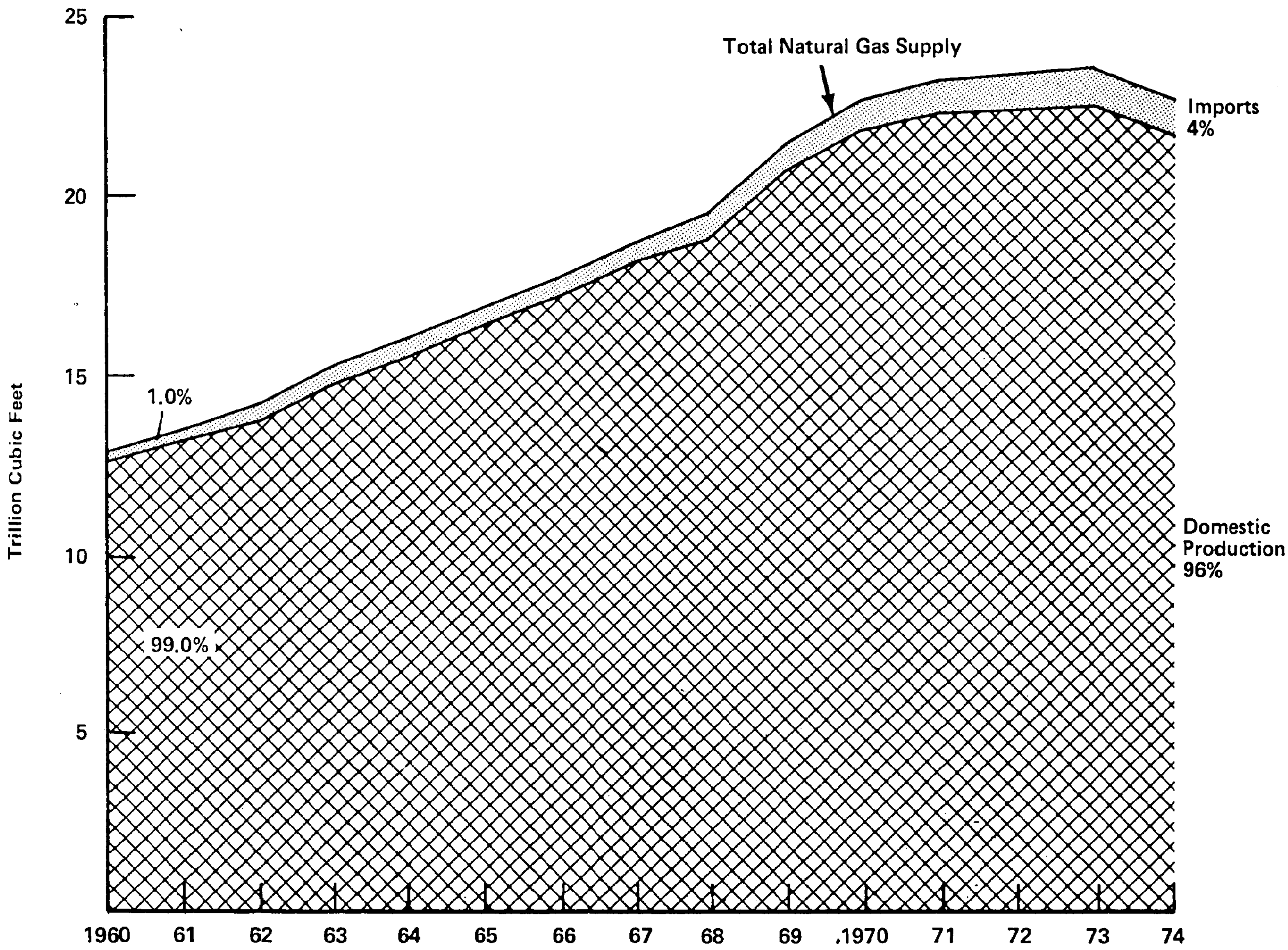
2. A continued long term growth in U.S. gross energy consumption of approximately 3.5%.

3. U.S. petroleum supply will remain fairly constant at approximately 3.5%.

4. U.S. petroleum production will rise at an annual rate of approximately 1%.

Figure B10

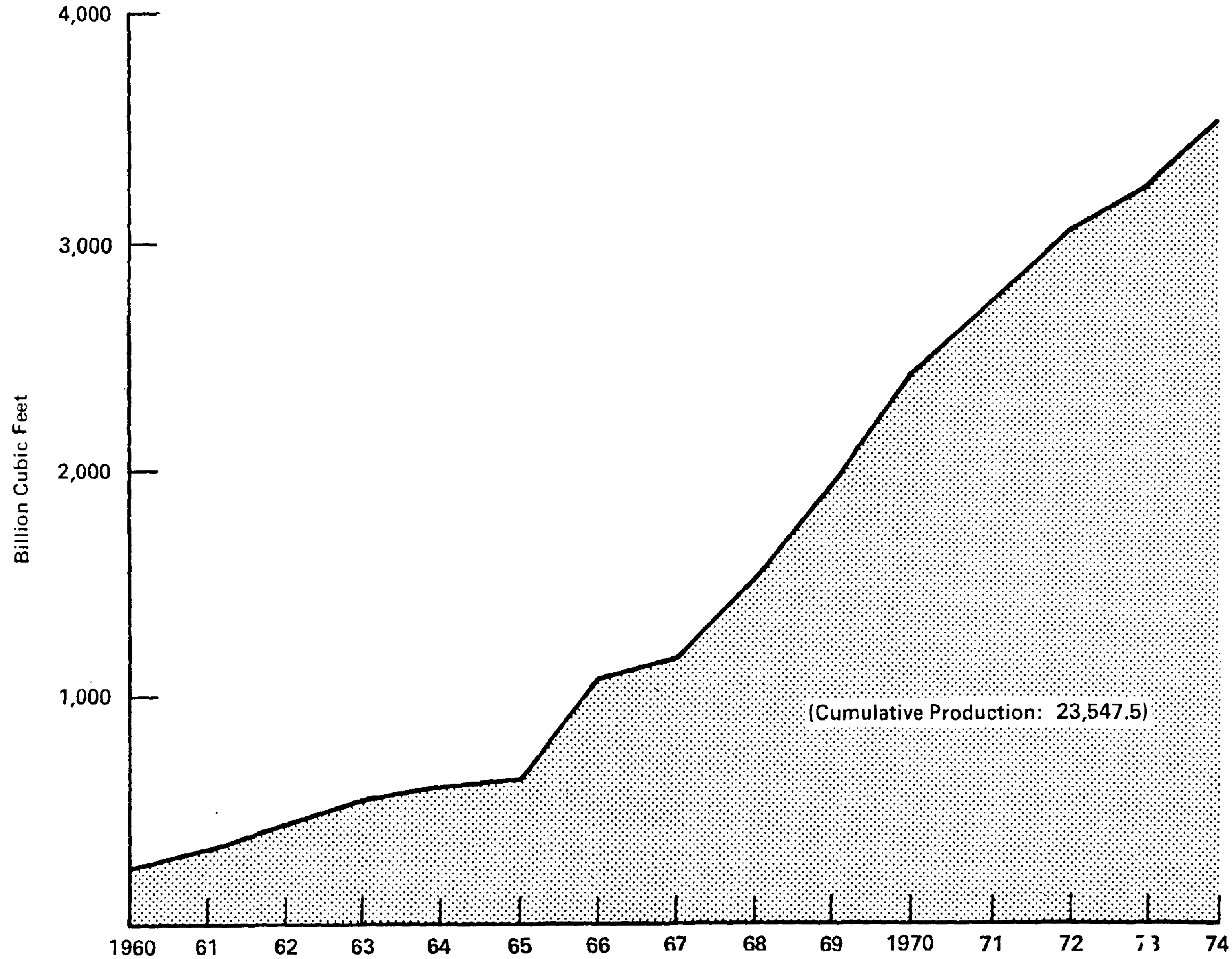
## U.S. Natural Gas Supply, 1960-74




SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

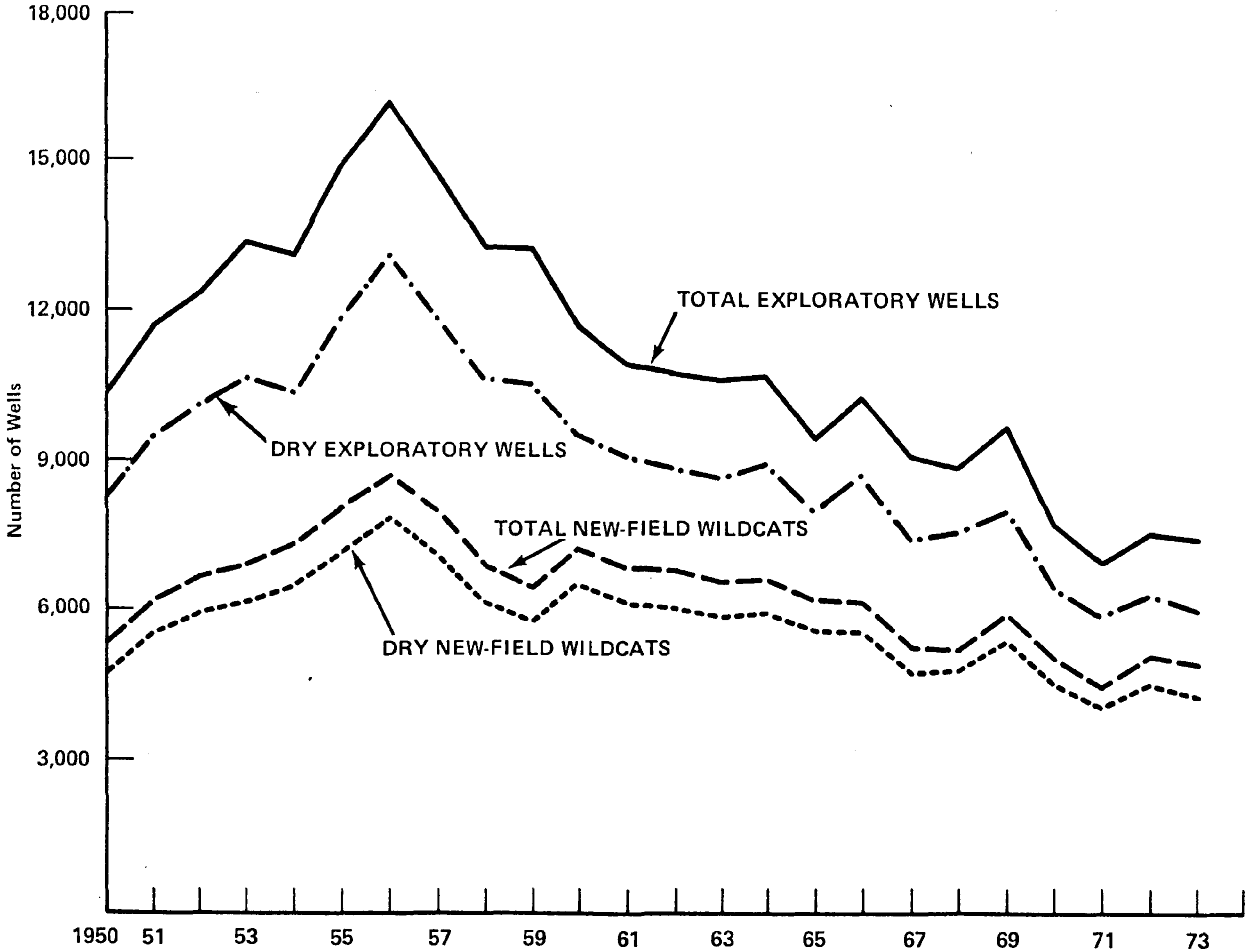
Figure B11

## Federal OCS Gross Natural Gas Production, 1960-74



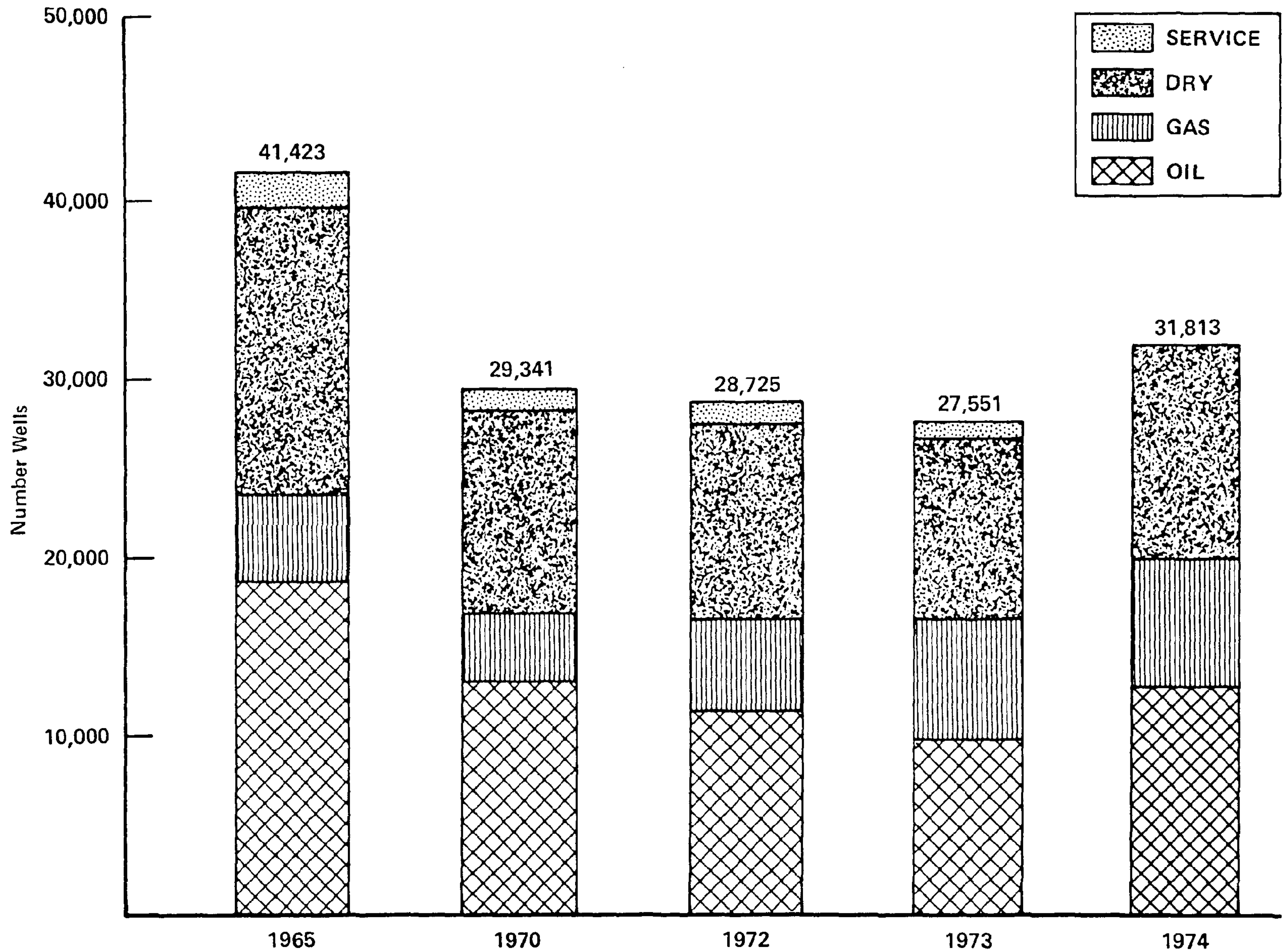

SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

# U.S. Exploratory Oil and Gas Wells, 1950-73




SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

## U.S. Oil and Gas Wells Drilled, 1965-74




SOURCE: Energy Perspectives, U.S. Dept. of Interior, 1975.

5. U.S. natural gas supply will remain relatively constant at approximately 22 trillion cubic feet annually.

6. U.S. natural gas production will remain relatively constant at approximately 21 trillion cubic feet annually.

7. Federal OCS areas will continue to account for approximately 11% of domestic petroleum production.

8. Federal OCS areas will continue to provide an increasing share of domestic natural gas production, climbing at an annual rate of approximately 9%.

Clearly, if significant policy changes were to be enacted, the supply and thus the price of oil and gas would undoubtedly be significantly affected. Such changes could be significant enough to dramatically accelerate OCS development. Those changes, however, are virtually impossible to accurately predict and, thus, the "business as usual" assumption is the most realistic. It must be borne in mind, however, that RPC's ultimate conclusions regarding impacts of OCS development could be varied upward or downward in accordance with presently unforeseen policy changes.

# ATTACHMENT BI

# GEOLOGIC FRAMEWORK AND METHODOLOGY FOR HYPOTHESIZING TEXAS OCS OIL AND GAS PRODUCTION

# GEOLOGIC FRAMEWORK AND METHODOLOGY FOR HYPOTHESIZING TEXAS OCS HYDROCARBON PRODUCTION PATTERNS

## Introduction

The design of a reasonable scenario for assessing coastal zone impact of outer continental shelf oil and gas development requires that hypothetical locations of oil and/or gas accumulations be made in a pattern most like what may in fact be found. This approximation is based on the review of the geological history and the present stratigraphic and structural framework of the western Gulf of Mexico continental shelf. Because of its proprietary nature in a competitive market, extensive detailed information on OCS potential hydrocarbon fields is not available. Only regional characteristics are included in this report to be used in scenario development.

The detailed location of new fields and calculations of new reserve additions, either for oil or gas, is not crucial to this study. Only time would tell if any estimates of future production characteristics are accurate. It is sufficient that technical appraisals indicate that one area is more prospective than another, at different depths of water and strata thickness, and as an oil or gas reservoir.

## Methodology

The procedure used in this report to estimate the probable future location of oil and gas production in the Texas OCS is as follows:

1. Published descriptions of the Texas OCS producing trends were reviewed;

2. Regions of present development and future petroleum potential in the Texas OCS were mapped, based on the descriptions of (1) above;

3. Regions of present activity in leasing and drilling were identified; and

4. Hypothetical sites for future petroleum finds were established, and their local characteristics of water depth and drilling depth were determined, based on (2) and (3) above.

In summary, this procedure uses only published information and qualified judgements in the development of hypothetical production patterns. It does not include area or site-specific geophysical data in the determination of reservoir locations. It does not attempt to model production schedules using such information as porosity, permeability, pressure, viscosity, or well driving mechanism as innate characteristics of any of the hypothetical finds.

## General Geological Framework

In the Jurassic Period (about 180 to 150 million years ago) the Gulf was a shallow enclosed sea similar to today's Caspian Sea. Extensive carbonate reefs from Florida to the Yucatan Peninsula may have restricted Gulf water interchange with the open ocean. Under arid climatic conditions, little fresh water and sediment entered the basin from North American streams, and evaporation from the Gulf surface resulted in hypersaline conditions. There were extensive salt and anhydrous gypsum deposits. The opening of the Gulf began in the Cretaceous period with a change in the North American tectonic setting. Nearly continuous Gulf sedimentation and subsidence has occurred since the beginning of the Cenozoic. Figure BI 1 shows the shape of the western Gulf of Mexico continental shelf at a depth of 200 meters.

The Tertiary and Pleistocene continental shelf strata is predominantly deltaic in origin, with considerable lateral distribution of sediments by paleo-Gulf currents. A striking characteristic of these deltaic deposits is the cyclic nature of alternating and interfingering sandstone and shale beds. Three major depositional areas may be recognized across the strata of any one age, determined mainly by proximity to the coast or sediment source and varying in the proportion of sand to shale (Figure BI 2). The percent of sandstone decreases from about 65 percent at the inner deltaic area to much less across the continental shelf and slope.

Regionally, each stratigraphic unit dips gulfward. The dip increases and the section thickens beyond the edge of the shelf. The sediment accumulation across the shelf during Tertiary time resulted in progressive shifting of the edge of the continental shelf towards the Gulf. The shelf edge for each progressively older producing trend will be found more towards the coast and deeper.

Sediments deposited on the outer shelf and upper slope through geologic time have the greatest potential for producing hydrocarbons due to the following:

1. This is where coarser nearshore sands interfinger with organic rich marine shales, providing an optimal sand/shale ratio for hydrocarbon source rock, movement, and reservoir;

2. Here the organic rich shales may be rapidly buried and protected, and not oxidized as they might be in shallow water;

FIGURE BI 1

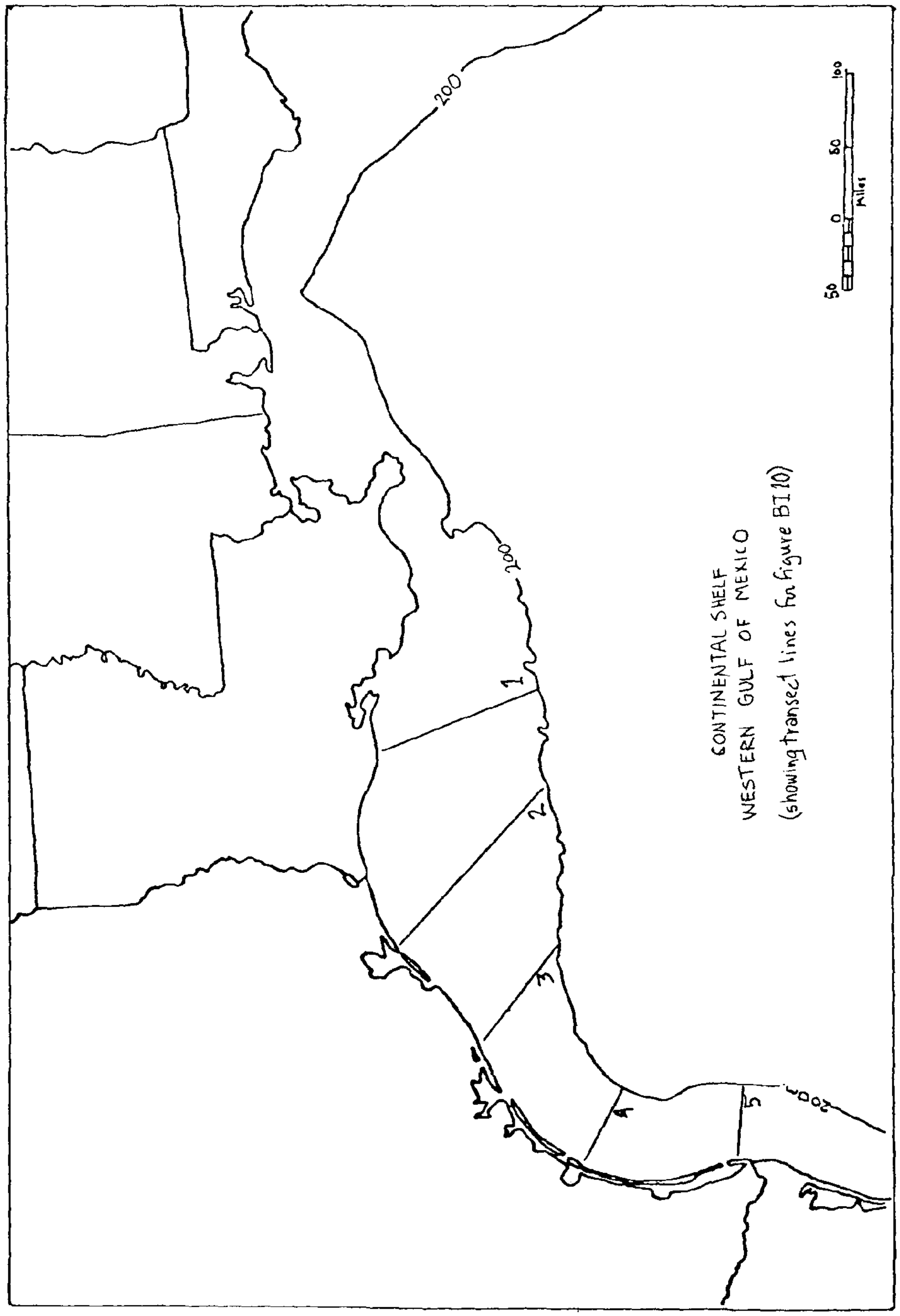
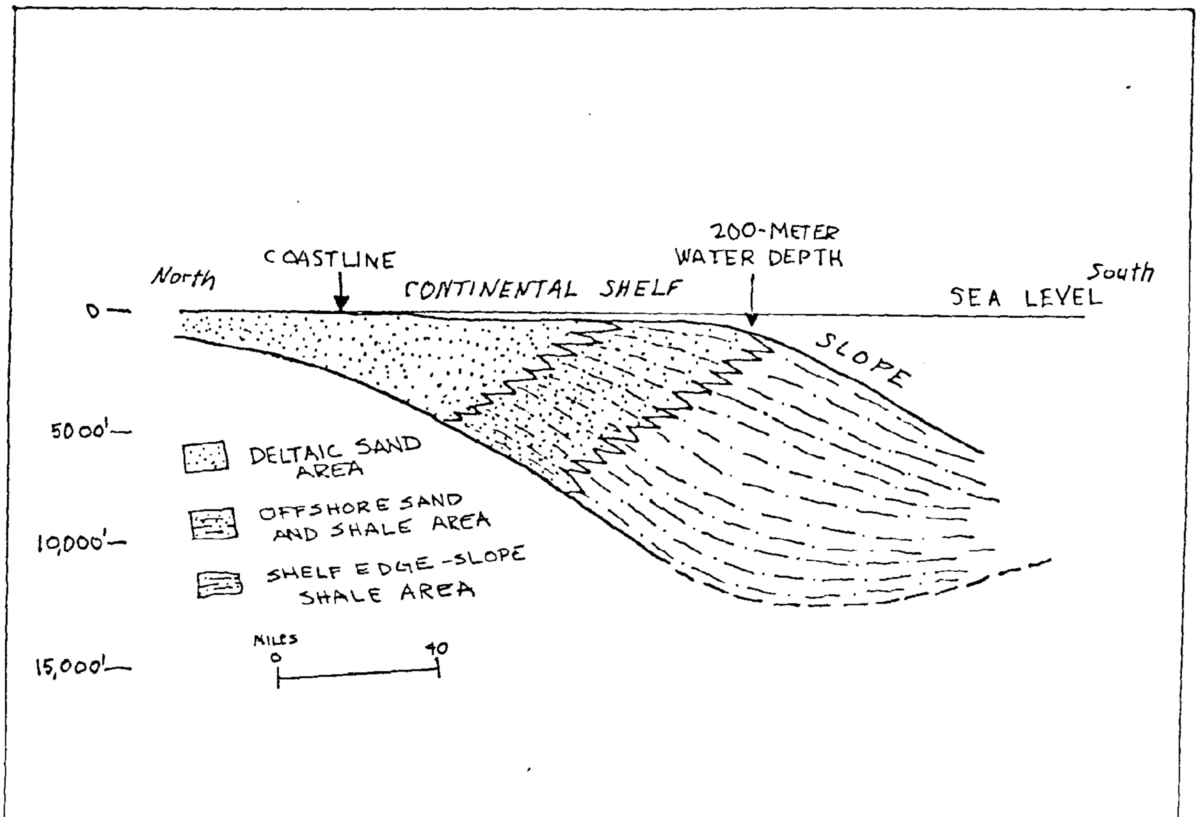

CONTINENTAL SHELF
WESTERN GULF OF MEXICO
(showing transect lines for figure BI10)
200
200
200
1
2
3
4
5
50
0
50
100
Miles

FIGURE BI 2




Schematic cross section of producing trend after initial development.

3. Increased sediment load over plastic-behaving salt and marine shale layers initiates salt flow, triggering the growth of salt domes and related faults which serve as reservoir traps (see Figure BI 3);

4. Pressure of overburden leads to heating of the clays, resulting in the 'cooking-out' of hydrocarbons[1].

The discovery and development of major petroleum reserves in strata of any one age in the Gulf has followed a general pattern of initial discovery of shallow accumulations on salt uplifts. As drilling was extended gulfward and to greater depths, significant new reserves were found in thicker marine sections correlative with the earlier finds.[2] This pattern of development may be expected to be similar to that for future OCS finds, especially in the upper Tertiary and Pleistocene, as discussed later.

## Descriptions of Producing Trends

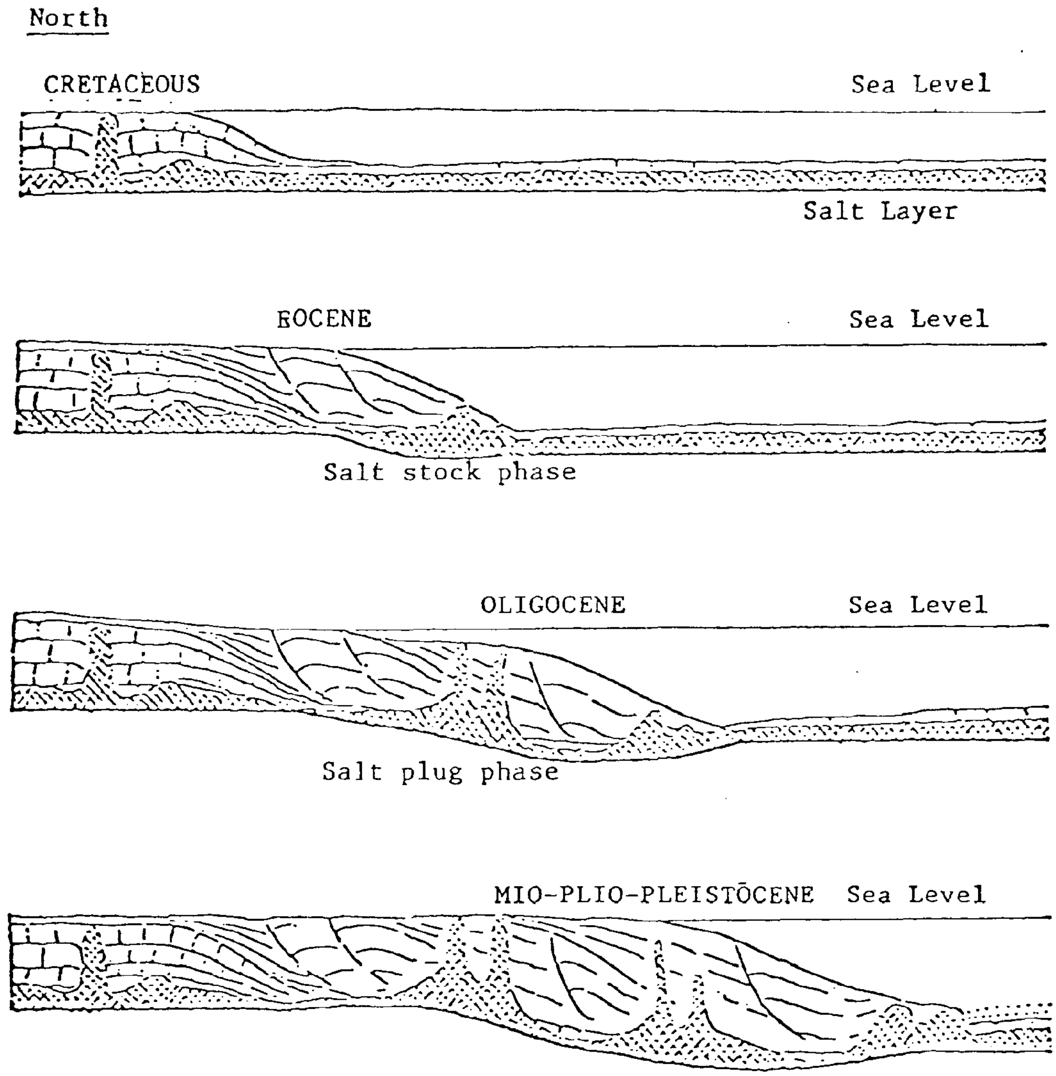
### I. Oligocene - Lower Miocene

Figure BI 4 illustrates Oligocene and Lower Miocene producing areas, and future Miocene probable and possible producing areas. The probable area was determined by the presence of favorable sand to shale ratios downdip or along the trend from present producing areas. The possible area was projected downdip to where sand content is estimated to be 5 to 10 percent. Future Oligocene production, mainly from the Frio Formation, will probably not extend much farther downdip. Both trends increase downdip in thickness to more than 6000 feet each. Drilling depths of 15,000 and 25,000 feet may be required to test parts of the Oliogocene and lower Miocene, respectively. Much of the future exploration and development will be for subtler, smaller, and deeper traps.[3]

### II. Upper Miocene

Structural elements of the mid-Tertiary time which affected both the Upper Miocene and Pliocene sedimentation pattern were the Mississippi Embayment, the Sabine Arch, the Houston Embayment, the San Marcos Arch, and the Rio Grande Embayment (Figure BI 5). Upper Miocene sedimentation was centered in the Mississippi Embayment. Optimum conditions for sizable accumulations of hydrocarbons in the Texas OCS section apparently did not exist. Either the Sabine Arch limited sediment transport from the east or the sediments were deposited before they reached the Houston Embayment.[4] Also the Texas upper Miocene shelf was apparently reduced, limiting the size of the basin. Therefore, the thickness of the Texas section is about

FIGURE BI 3




Schematic illustration of the development of the Tertiary Gulf Coast paraliageosyncline, as associated with the movement of salt; under progressivel loading:

(a) Lateral displacement of salt under differential loading pressure and growth of salt stocks (salt stock phase of diapirism).
(b) Growth of salt plugs from salt stock (salt plug phase of diapirism during prograding sedimentation).

Salt dome development in the Gulf Coast Geosyncline

(from Wilhelm, O. and M. Ewing. (1972) Geology and history of the Gulf of Mexico. G.S.A. Bull. v83. pp575-600.)

FIGURE BI 4

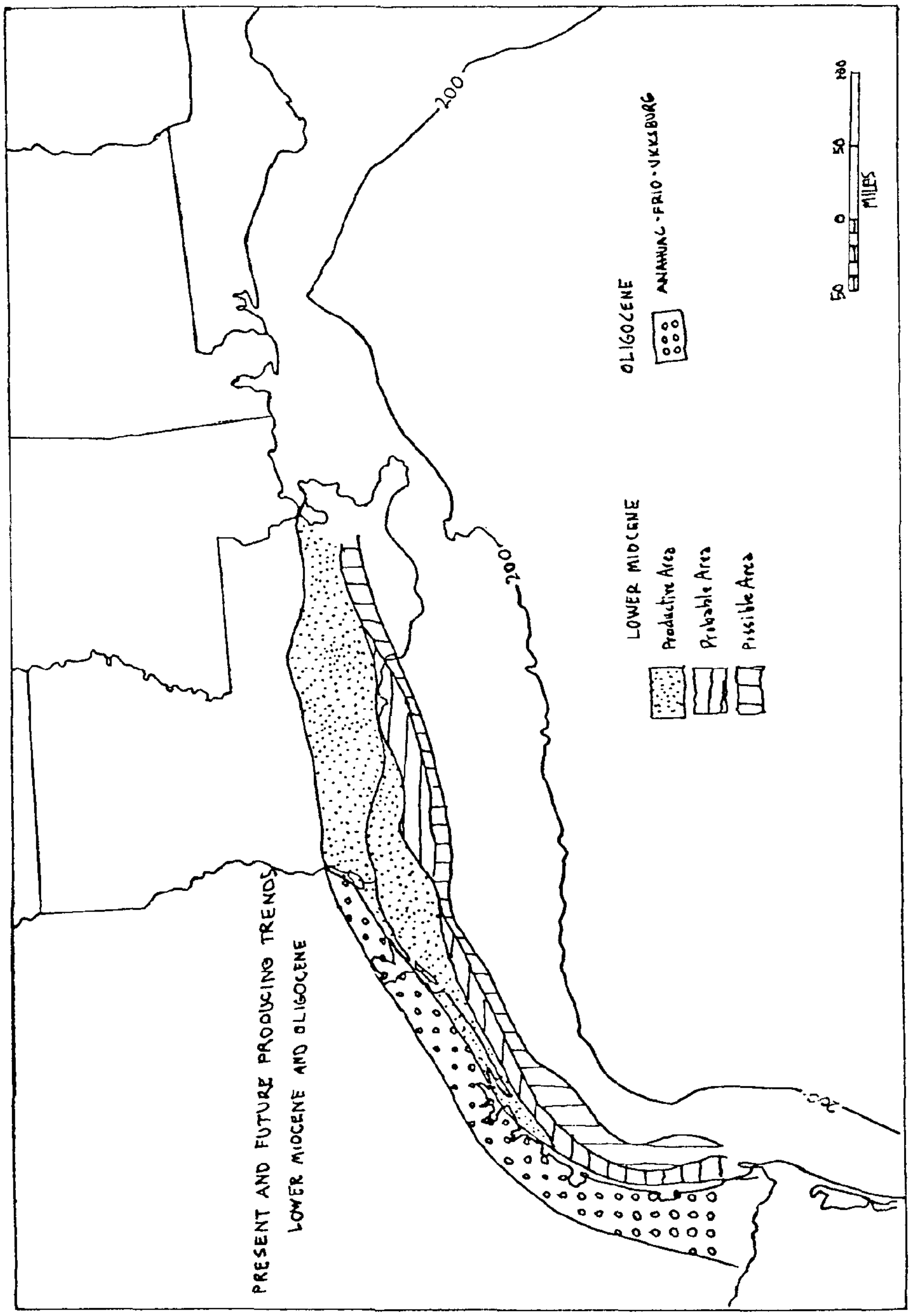
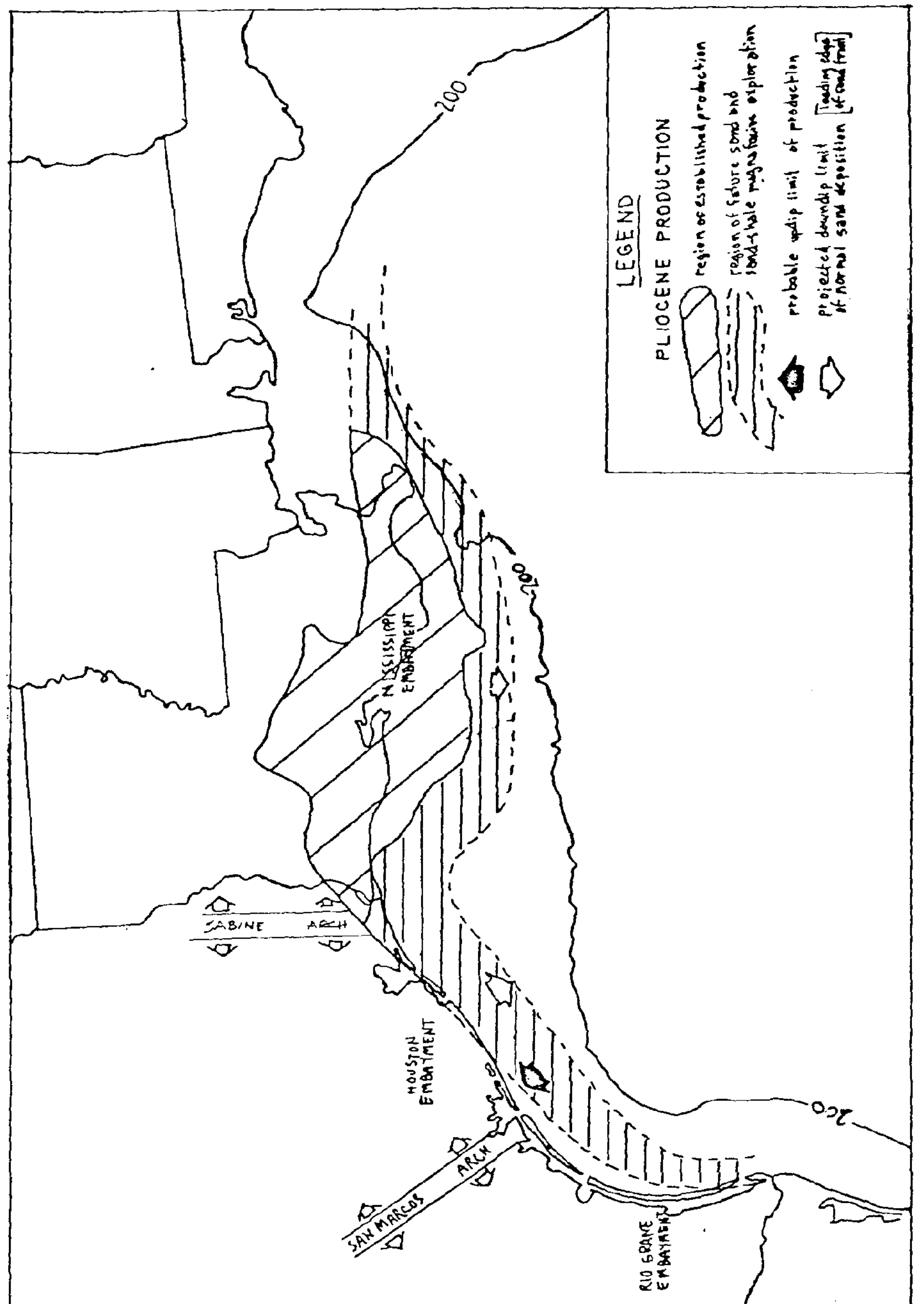

PRESENT AND FUTURE PRODUCING TRENDS
LOWER MIOCENE AND OLIGOCENE
LOWER MIOCENE
Productive Area
Probable Area
Possible Area
OLIGOCENE
ANAHUAC - FRIO - VICKSBURG
50
0
50
100
MILES
200
200
200

FIGURE BI 5



LEGEND
PLIOCENE PRODUCTION
region of established production
region of future sand and sand-shale megafacies exploration
probable updip limit of production
projected downdip limit of normal sand deposition
[leading edge of sand front]
200
100
MISSISSIPPI EMBAYMENT
SABINE ARCH
HOUSTON EMBAYMENT
SAN MARCOS ARCH
RIO GRANDE EMBAYMENT

7,000 feet compared to 10,000 feet in Louisiana. There is an estimated 13,000 cubic miles of upper Miocene rocks in the Texas OCS, about 30% of which is reservoir rock. Future development will extend along current trends and exploration may indicate reserves in the deeper shale area downdip, where only gas is expected to be found (Figure BI 6).

III. Pliocene

The Pliocene is structurally and stratigraphically similar to the older Miocene section. Although the trend accumulated half the volume of sediment that occurs in the upper Miocene, conditions for petroleum generation and storage evidently were significantly better. The Texas OCS Pliocene is only 4,000 feet thick with 3,000 cubic miles of rock. Two distinct provinces occur in the Texas Pliocene. The east Texas region has the highest density of salt domes of all the producing trends. The south Texas region is characterized by the lack of salt domes and fault blocks with the down thrown block to the Gulf. Figure BI 6 indicates the probable limits of future production in this trend.

IV. Pleistocene

The Pleistocene section thickens from 1,000 feet along the coast to more than 10,000 feet at the shelf edge in the east Texas - Louisiana region (Figure B1 7). It thins rapidly to the east and west across the shelf, being no more than 4,500 feet thick in south Texas. Those parts of Texas and Louisiana where thickness is less than 2,000 feet and where the sediment is mostly deltaic sand, lacking in hydrocarbon source rock, are not considered to be favorable for future production.[2] The area between the 2,000 and 5,000 foot contours is similar to the highly productive Louisiana Pleistocene and includes the transition between deltaic sands and offshore sand and clays with many salt domes intruding. The most promising Pleistocene section is the outer shelf and shelf edge sand and shale area more than 7,000 feet thick. The amount of reservoir rock decreases with depth from 50%.

## Future Potential - Development of Hypothesis

The geologic information necessary to describe mock patterns of future OCS development includes the general location of favorable producing areas, the depth of strata to be drilled, the depth of water at the area, and estimates of the volume of oil and gas which may be produced.

Most of the exploratory and production activity in the Texas OCS has been within 50 to 100 miles from shore, northeast of Matagorda Island

FIGURE BI 6

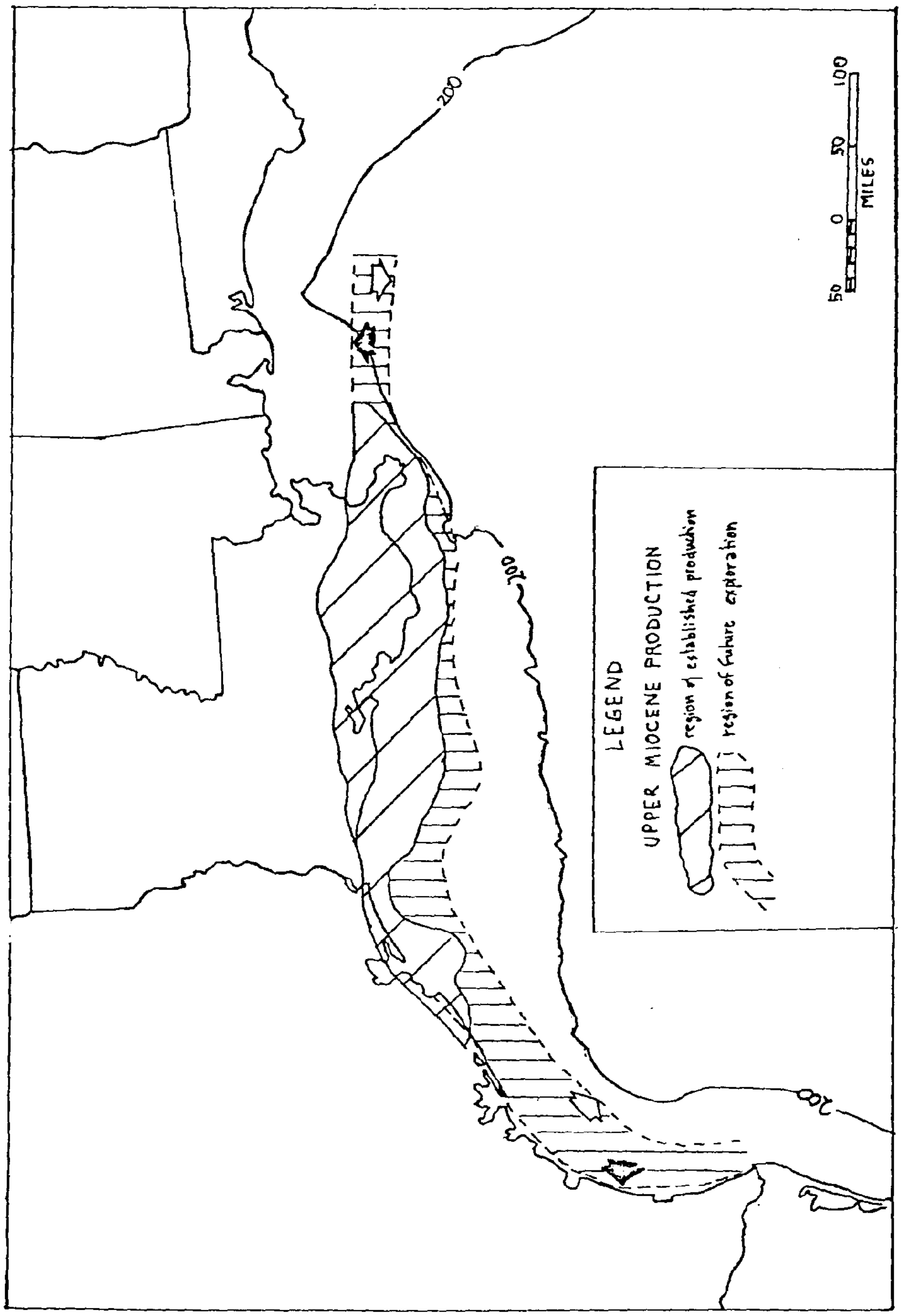
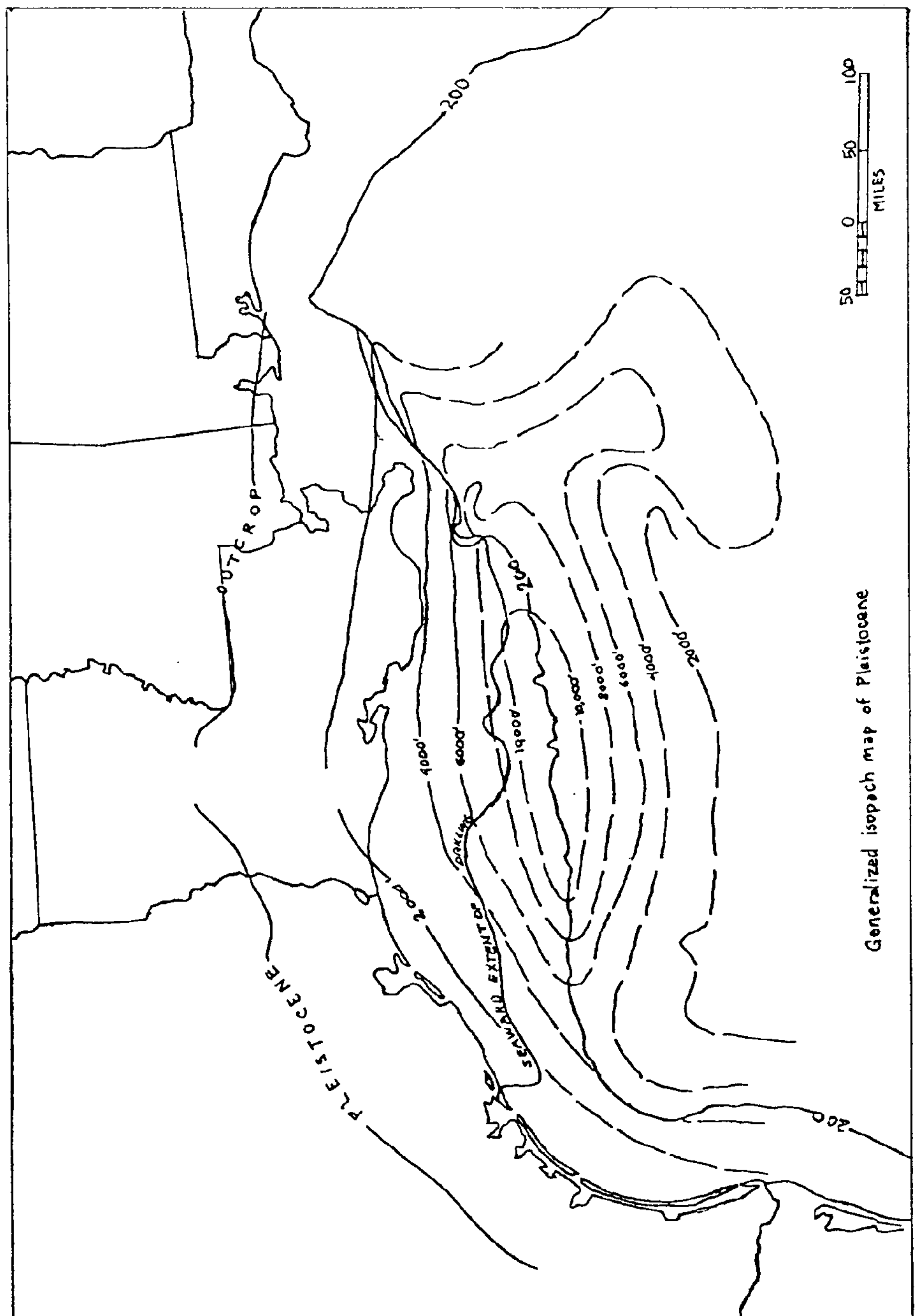

LEGEND
UPPER MIOCENE PRODUCTION
region of established production
region of future exploration
50 0 50 100
MILES
200
200
200

FIGURE BI 7




Generalized isopach map of Pleistocene

(Figure BI 8). The depth of water is less than 40 meters. Most wells extend between 8,000 and 12,000 feet deep. Production in this area is mostly from the Miocene and Pliocene offshore sand and shale deposits (Figure BI 9). Further offshore, these trends occur at greater depth and have less reservoir rock (Figure BI 10). To the southwest the overall section thickness decreases.

The expected regions of future activity are shown in Figure BI 11, compiled from Figures BI 4,BI 5, and BI 6. This map in comparison to figure BI 9 shows three expected patterns. Drilling in the Miocene and Pliocene will extend along present trend to south Texas. Drilling may also be expected to extend to greater depth downdip in these producing sections. The third pattern is activity along the east Texas outer shelf edge in the Pleistocene.

FIGURE BI 8

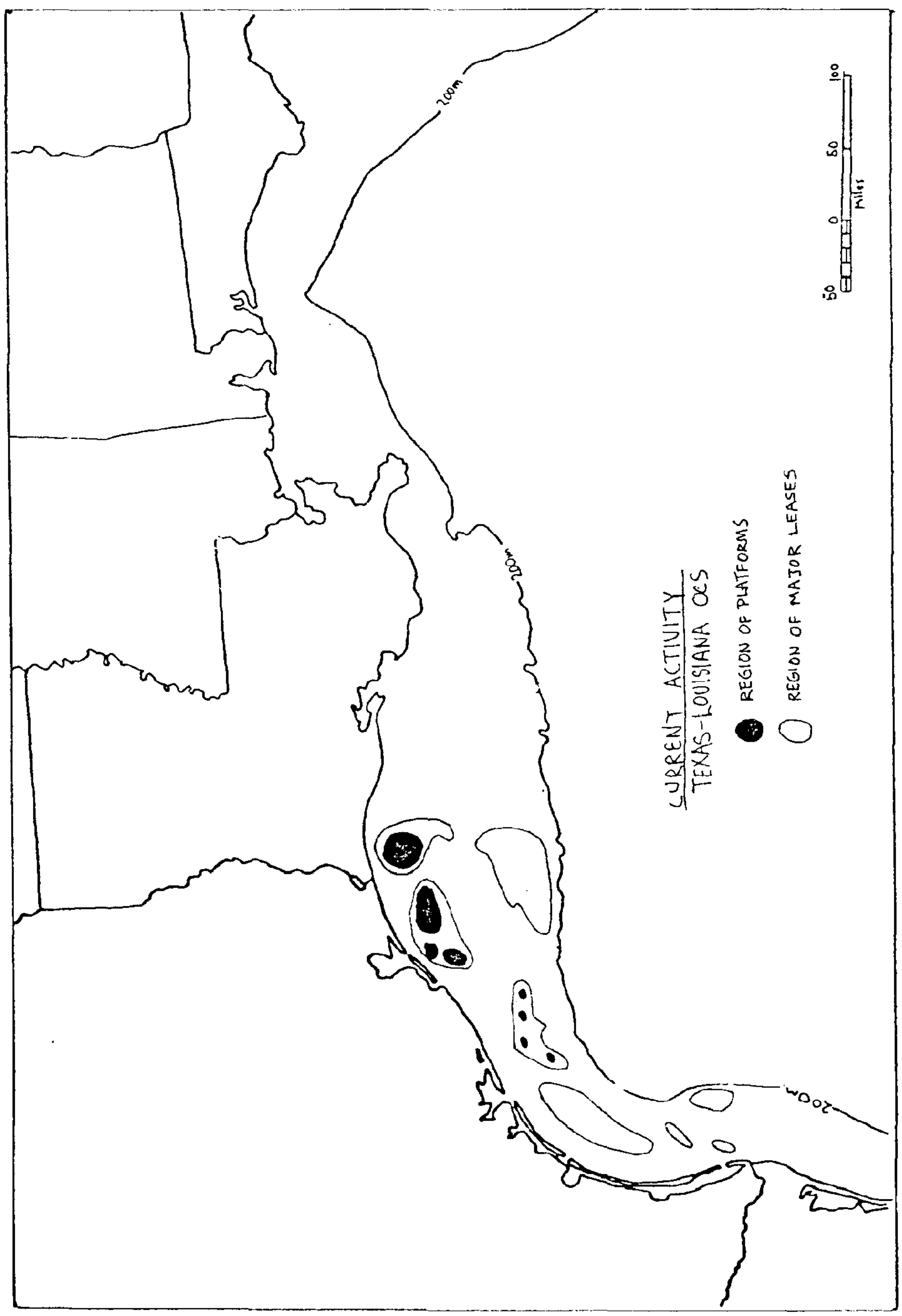
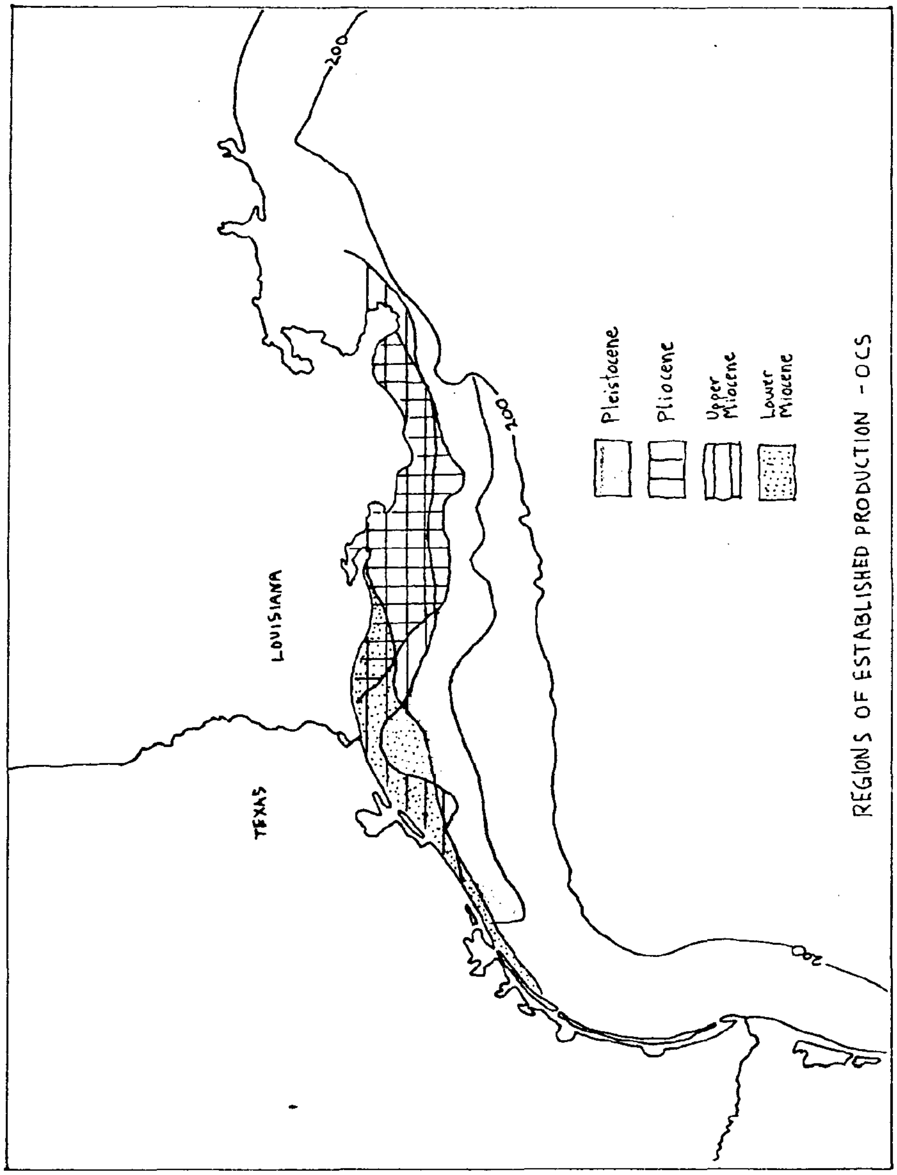
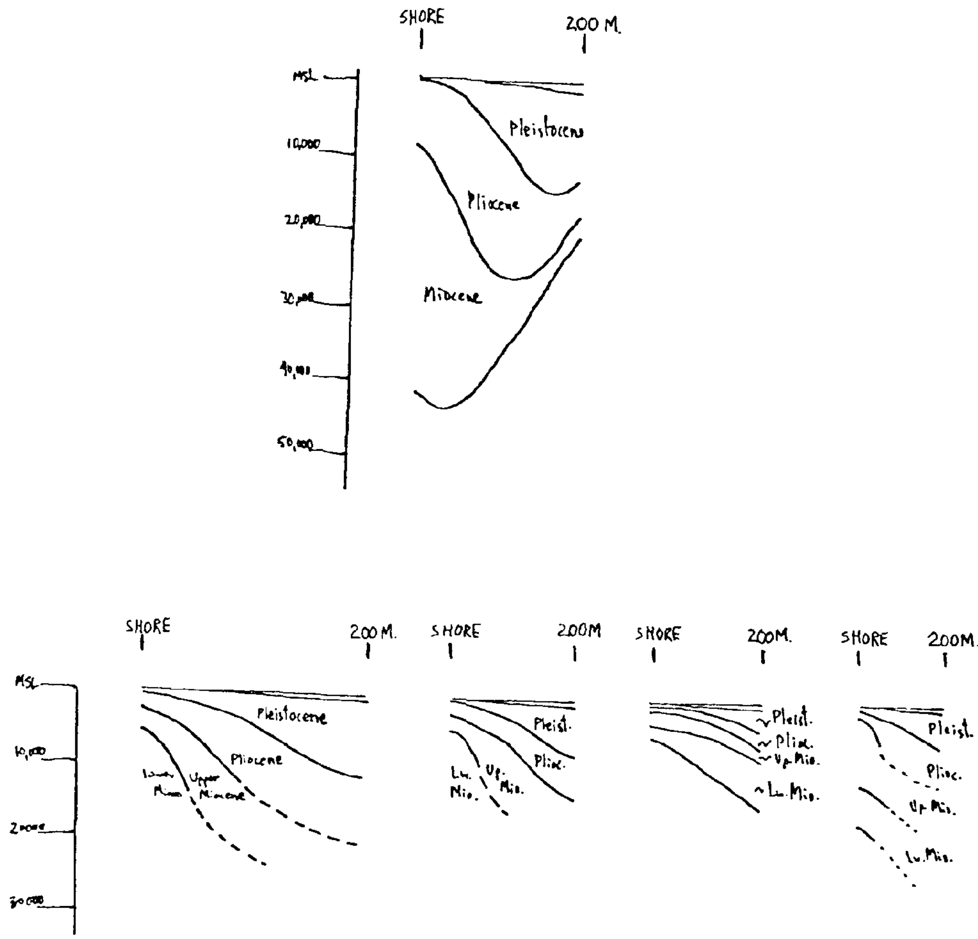

CURRENT ACTIVITY
TEXAS-LOUISIANA OCS
REGION OF PLATFORMS
REGION OF MAJOR LEASES
200m
200m
200m
50
0
50
100
Miles

FIGURE BI 9



REGIONS OF ESTABLISHED PRODUCTION - OCS

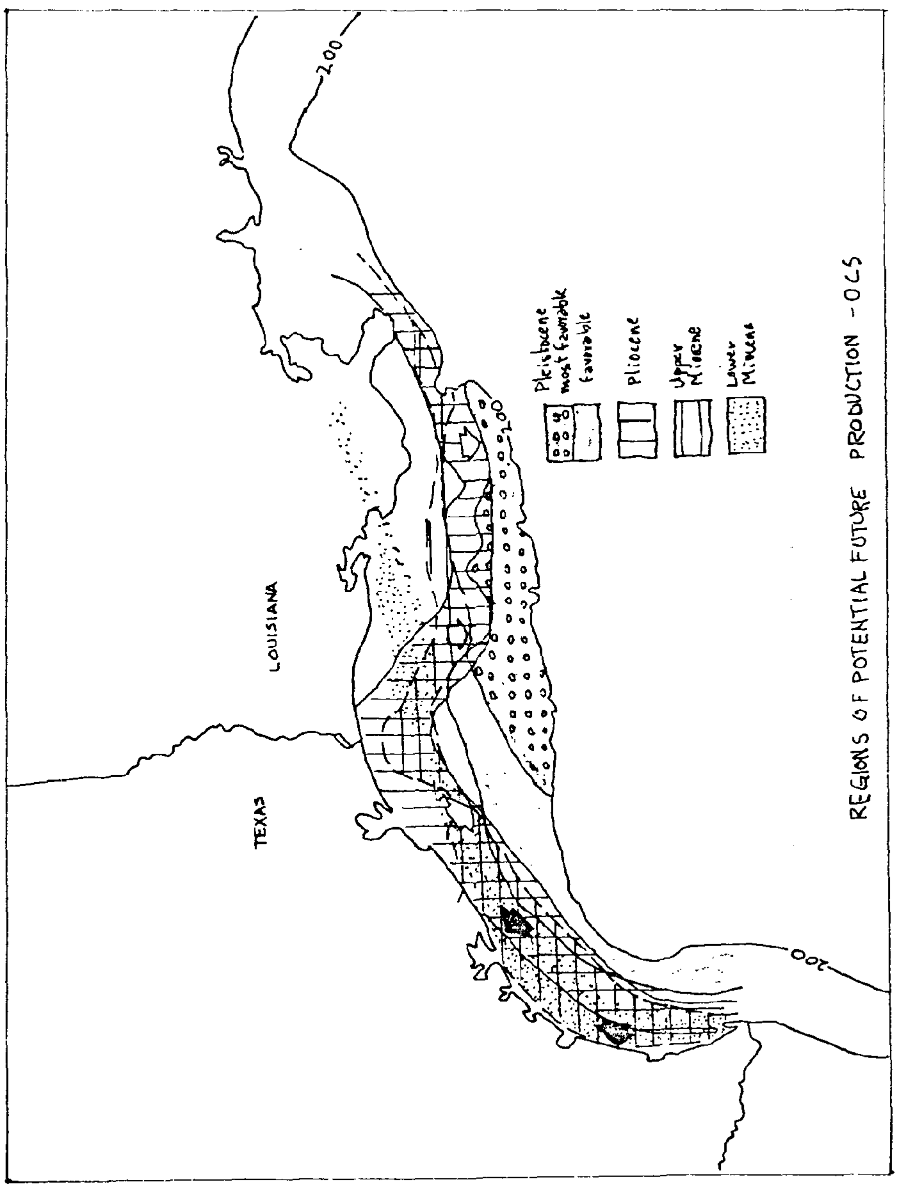
FIGURE BI 10




Cross-sections in western Gulf of Mexico

transects as shown in figure BI1
Horizontal Scale about 1" = 100 miles
Depth in feet

FIGURE BI 11


REGIONS OF POTENTIAL FUTURE PRODUCTION - OCS
Pleistocene most favorable
favorable
Pliocene
Upper Miocene
Lower Miocene
TEXAS
LOUISIANA
200
200
200

Footnotes to Attachment BI

1. U.S. Department of the Interior (1974) Final Environmental Statement for Proposed OCS Oil and Gas General Lease Sale. pp. 83-84.

2. Powell, L. C. and H. O. Woodbury (1971) Possible Future Petroleum Potential of Pleistocene, Western Gulf Basin. AAPG Mem. 15(2) p. 813.

3. Tipsword, H. L., W. A. Fowler, Jr. and B. J. Sorrell (1971) Possible Future Petroleum Potential of Lower Miocene - Oligocene, Western Gulf Basin. AAPG Mem. 15(2). p. 854.

4. Shinn, A. D. (1971) Possible Future Petroleum Potential of Upper Miocene and Pliocene, Western Gulf Basin. AAPG Mem. 15(2) p. 834.

ATTACHMENT BII

PIPELINES IN THE TEXAS FEDERAL OCS

## PIPELINES

Over seventy trunk or gathering pipelines extend from the Texas OCS or the federal OCS off Texas to the Texas barrier islands or to the Texas coast where there are no barrier islands. Twelve of these trunk or gathering lines extend beyond the three marine league line into the federal OCS. (see Map BII 1 and Figure BII 1.)

Most of the pipelines which are situated wholly within the Texas OCS carry gas and are in the 2 3/8" to 12" size range. Although a few are larger and some carry oil, these are relatively few.

Of primary concern are the twelve trunk or gathering lines which are situated in the federal OCS off Texas.

1. Pipeline #2 on Map BII 1 is a 16-mile gathering line connecting to a trunk line situated in the federal OCS off Louisiana. Pipeline #2 gathers gas from tract number 129 in the High Island/East Addition area. It has a 12" diameter and is owned by Tidal Pipeline Co.

2. Pipeline #9 is a 16" gas line extending approximately 33 miles from tract number 88 in the High Island area to a trunk line in Louisiana. It carries gas and is owned by United Gas Pipeline Co.

3. Pipeline #10 on Map BII 1 is a 16" natural gas pipeline. It gathers production from tract number 88 in the High Island area and carries it 26 miles to a natural gas trunk line in Texas. It is owned by Natural Gas Pipeline Co.

4. Pipeline #13 extends approximately 32 miles from tract number 52 in the High Island area to a trunk line in Louisiana. It is a 16" gas line owned by Transcontinental Gas Pipeline Co.

5. Pipeline #16 on Map BII 1 is a 4 1/2" oil line extending from tract number 52 in the High Island area to the Texas coast. That distance is approximately 12 miles. The line is owned by Chevron Oil Co.

6. Pipeline #20 is a 16" gas line which gathers production from tract number 136 in the High Island area. It carries such production approximately 56 miles to Texas City, Texas. It is owned by the Black Marlin Pipeline Co.

7. Pipeline #21 is a 6" gas line which gathers production from tract number 140 in the High Island area and carries it approximately 3 miles to feed into pipeline number 20. It too, is owned by Black Marlin.

8. Pipeline #26 gathers production from tract number 296 in the Galveston area and carries it approximately 3 miles to feed into pipeline #27. It is a 20" gas line owned by Blue Dolphin Pipeline Co.

9. Pipeline #27 gathers gas from tract number 288 in the Galveston area and carries it approximately 40 miles to the Texas shores. It, like pipeline #26 which feeds into it, is a 20" gas line and is owned by Blue Dolphin.

10. Pipeline #34, which is fed by both numbers 33 and 35 (see below) is a 30" gas line. It extends from tract number 538 in the Brazos area to Texas shore, approximately 28 miles away. It is owned by Transcontinental gas Pipeline Co.

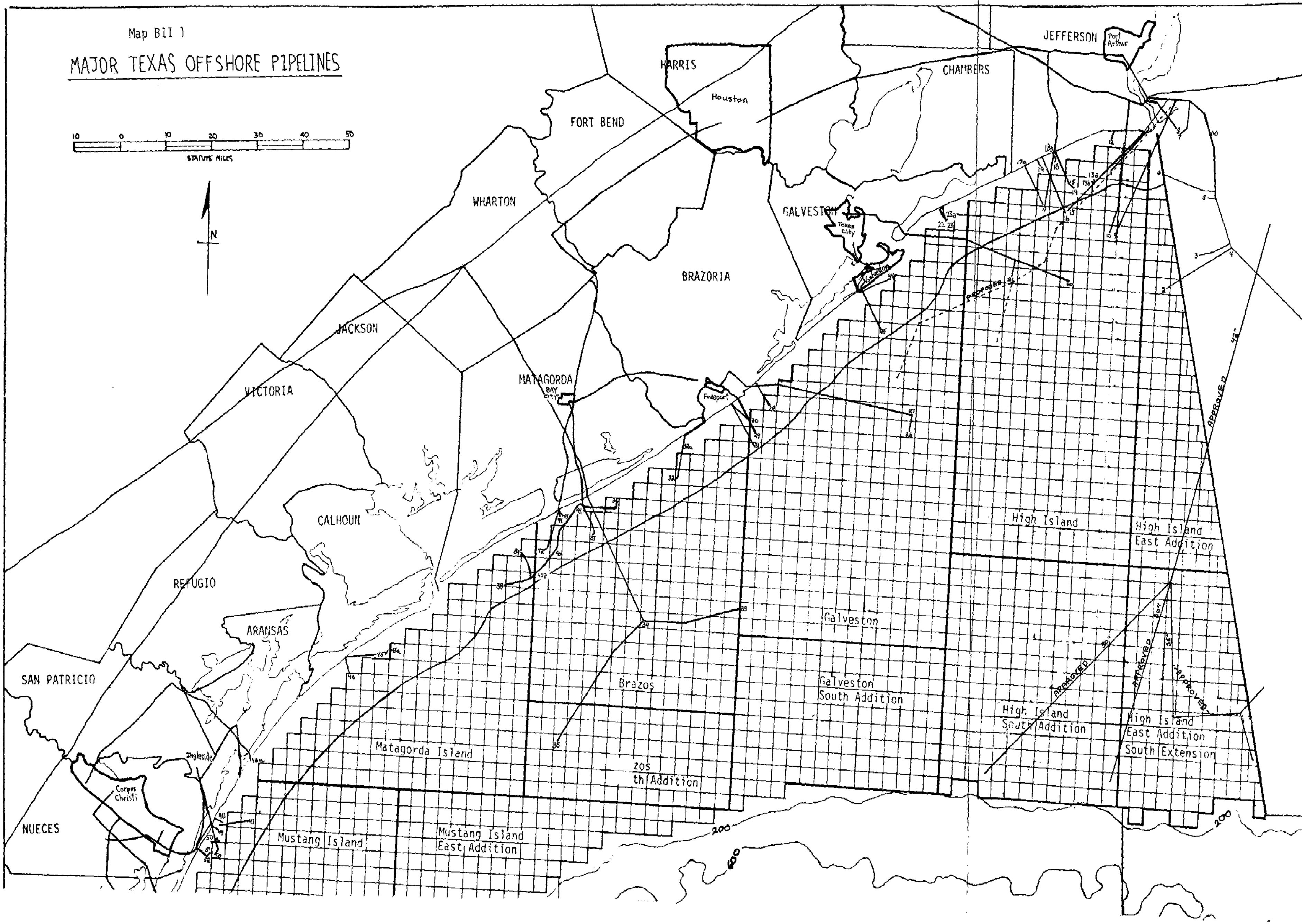
11. Pipeline #33 on Map BII 1 is a 20" gas line extending from tract number A-1 in the Brazos area down to tract number 541 in the same area and then westward to join pipeline #34. Its total length is approximately 22 miles and is owned by Transcontinental.

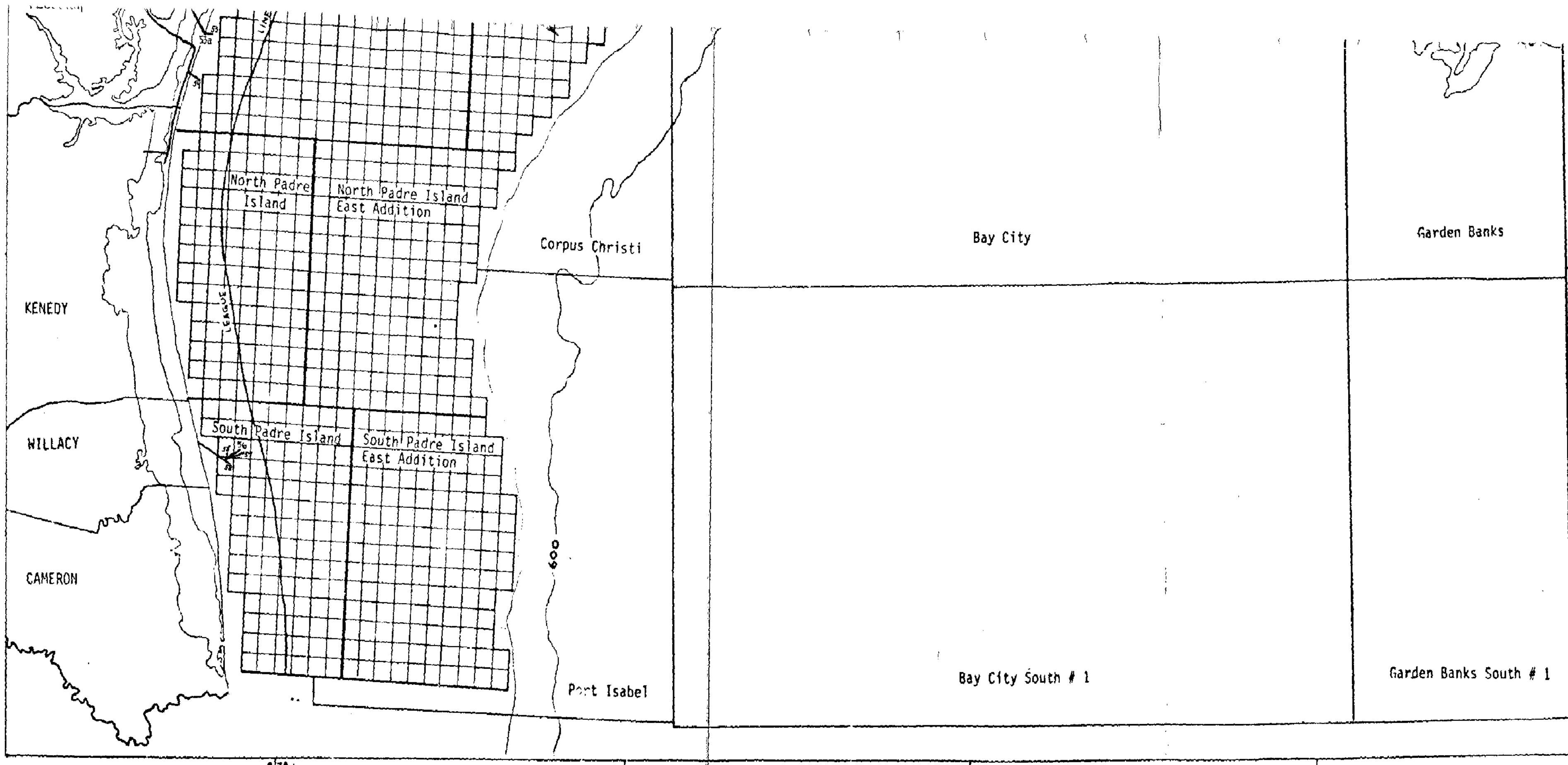
12. Pipeline #35 originates in tract number A-76 in the Brazos/South Addition area and extends approximately 32 miles to feed into pipeline #34. It is a 20" gas line owned by Transcontinental.

Thus, the total mileage of pipeline seaward of the three league line in the federal OCS off Texas is approximately 147 miles.

Map BII 1

# MAJOR TEXAS OFFSHORE PIPELINES





KENEDY
WILLACY
CAMERON
North Padre Island
North Padre Island East Addition
South Padre Island
South Padre Island East Addition
LEAGUE
LINE
600
Corpus Christi
Port Isabel
Bay City
Bay City South # 1
Garden Banks
Garden Banks South # 1
27°N
26°N
97°W
96°W
95°W
94°W

| Pipeline Number (From Map ) | Texas General Land Office Easement No. | Size | Product | Owner |
|---|---|---|---|---|
| 1 | | 12" | Gas | Tidal Pipeline Co. |
| 2 | | 12" | Gas | Tidal Pipeline Co. |
| 3 | | 6" | Gas | Tidal Pipeline Co. |
| 4 | | 16" | Gas | Tidal Pipeline Co. |
| 5 | | 6" | Gas | Tidal Pipeline Co. |
| 6 | | 10" | Gas | Tidal Pipeline Co. |
| 7 | | 10" | Gas | Chevron Oil Co. |
| 8 | | 18" | Gas | Chevron Oil Co. |
| 9 | 2184 | 16" | Gas | United Gas Pipeline Co. |
| 10 | 2391 | 16" | Natural Gas | Natural Gas Pipeline Co. |
| 11 | 1955 | 10" | Gas | Transcontinental Gas Pipeline Co. |
| 12 | 1557 | 6 5/8" | Oil | Zapata - C&K |
| 13 | 1833 | 16" | Gas | Transcontinental Gas Pipeline Co. |

Figure BII 1 (con't.)

Pipeline/Gulf of Mexico
(To accompany Map BII 1)

| Pipeline Number (From Map ) | Texas General Land Office Easement No. | Size | Product | Owner |
|---|---|---|---|---|
| 13a | 2815 | 10" | Gas | Transcontinental Gas Pipeline Co. |
| 13b | 2850 | 2 7/8" | Gas | Mitchell Energy Offshore |
| 14 | 1852 | 12" | Gas | United Gas Pipeline Co. |
| 15 | 1827<br>1816 | 16"<br>8 5/8" | Gas<br>Oil | United Gas Pipeline Co.<br>Atlantic Richfield Co. |
| 16 | 2421 | 4 1/2" | Oil | Chevron Oil Co. |
| 17 | 2018 | 12" | Gas | Pennzoil Pipeline Co. |
| 17a | 2005 | 4 1 2" | Gas | King Resources Co. |
| 18 | 1572 | 3" | Gas | Occidental Petroleum Corp. |
| 18a | 1571 | 4 1/2"<br>2 1/2" | Gas<br>Oil | Occidental Petroleum Corp. |
| 19 | 445 | 4" | | Pan American Petroleum Corp. |
| 20 | 1487 | 16" | Gas | Black Marlin Pipeline Co. |
| 21 | | 6" | Gas | Black Marlin Pipeline Co. |

Figure BII 1. (Cont.) Pipeline/Gulf of Mexico
(To accompany Map BII 1)

| Pipeline Number (From Map ) | Texas General Land Office Easement No. | Size | Product | Owner |
|---|---|---|---|---|
| 22 | 2470 | 8" | Gas | Natural Gas Pipeline Co. |
| 23 | 2465 | 4" | Oil | Mitchell Energy Offshore |
| 23a | 2461 | 2 3/8" | Oil | Mitchell Energy Offshore |
| 24 | 3252 | 6 5/8" | Gas | Tejas Gas Corporation |
| 25 | 3089 | 3 1/8" | Oil | Houston Oil and Minerals |
| 26 | | 20" | Gas | Blue Dolphin Pipeline Co. |
| 27 | 3000 | 20" | Gas | Blue Dolphin Pipeline Co. |
| 28 | 3209 | 8" | Gas | Houston Pipeline Co. |
| 29 | 2605 | 8 5/8" | Oil | Mobil Oil Corp. |
| 30 | 2565 | 8 5/8" | Oil | Houston Pipeline Co. |
| 31 | 3249 | 3" | Gas | Houston Pipeline Co. |
| 32 | 3225 | 8 5/8" | Gas | Pipeline Technologists |
| 32a | 2857 | 8 5/8" | Gas | Coastal States Gas Prod. Co. |

Figure BII 1. (con't.)

Pipeline/Gulf of Mexico
(To accompany Map BII

| Pipeline Number (From Map ) | Texas General Land Office Easement No. | Size | Product | Owner |
|---|---|---|---|---|
| 33 | | 20" | Gas | Transcontinental Gas Pipeline Co. |
| 34 | 2114 | 30" | Gas | Transcontinental Gas Pipeline Co. |
| 35 | | 20" | Gas | Transcontinental Gas Pipeline Co. |
| 36 | 1453 | 8 5/8" | Gas | Lo-Vaca Gathering Co. |
| 37 | 1453 | 8 5/8" | Gas | Lo-Vaca Gathering Co. |
| 38 | 1592 | 12" | Gas | Lo-Vaca Gathering Co. |
| 39 | 3170 | 6 5/8" | Gas | Superior Oil Company |
| 40 | 1454 | 10 3/4" | Gas | Lo-Vaca Gathering Co. |
| 40a | 1567 | 12" | Gas | Lo-Vaca Gathering Co. |
| 41 | 1459 | 16" | Gas | Lo-Vaca Gathering Co. |
| 42 | 2597 | 6" | Oil | Monsanto Co. |
| 43 | 2588 | 5 5/8" | Gas | North American Royalties, Inc. |
| 44 | 2587 | 5 5/8" | Gas | North American Royalties, Inc. |

Figure BII 1. (con't.)

Pipeline/Gulf of Mexico
(To accompany Map BII 1)

| Pipeline Number (From Map ) | Texas General Land Office Easement No. | Size | Product | Owner |
|---|---|---|---|---|
| 45 | 2926 | 10" | Gas | Corpus Christi Oil & Gas Co. |
| 45a | 2927 | 8 5/8" | Gas | Corpus Christi Oil and Gas Co. |
| 46 | 3226 | 10 3/4" | Gas | Pipeline Technologists |
| 46a | 1566 | 12" | Gas | Lo-Vaca Gathering Co. |
| 47 | 2893 | 6 5/8" | Gas | OXY Petroleum |
| 48 | 2882 | 6" | Gas | Sun Oil Co. |
| 49 | 1836<br>1826 | 4"<br>6" | Gas<br>Gas | Shell Oil Co.<br>Gulf Oil Co. |
| 50 | 1717 | 8" | Gas | United Gas Pipeline Co. |
| 50a | 1630 | 8" | Gas | United Gas Pipeline Co. |
| 51 | 1745 | 4 1/2" | Gas | Texaco, Inc. |
| 52 | 2560 | 6" | Gas | Reynolds Mining Corp. |
| 53 | 1641 | 10" | Gas | Texas Eastern Transmission |
| 53a | 2849 | 10" | Gas | Chevron Oil Co. |

Figure BII 1. (con't.)

Pipeline/Gulf of Mexico
(To accompany Map BII 1)

| Pipeline Number (From Map ) | Texas General Land Office Easement No. | Size | Product | Owner |
|---|---|---|---|---|
| 54 | 2790 | 3 1/2" | Gas | Reserve Gas Systems, Inc. |
| 55 | 2933 | 4 1/2" | Oil | Mobil Oil Corp. |
| 56 | 2933 | 4 1/2" | Oil | Mobil Oil Corp. |
| 57 | 2933 | 4 1/2" | Oil | Mobile Oil Corp. |
| 58 | 3115 | 8 5/8" | Oil | Mobile Oil Corp. |

# APPENDIX C

# DESCRIPTIONS OF STRIKES

## DESCRIPTIONS OF STRIKES

The following descriptions are based on Appendix B and the original data thereof. The twenty-one strike descriptions which follow provide a range in the assumptions of location, size and other characteristics of OCS development, and include for each strike area:

1. Tracts to be offered in sales 44 and 47;
2. Tracts leased in each sale as percentage of tracts offered;
3. Tracts explored as percentage of tracts leased in sales 44, 47, and in previous sales;
4. Tracts developed as percentage of tracts explored resulting from sales 44, 47, and from previous sales;
5. Tracts put into production as percentage of tracts developed resulting from sales 44, 47, and from previous sales;
6. Amount of hydrocarbon production from each producing tract;
7. Drilling depth range to a given producing trend; and
8. Water depth range across the strike area.

The descriptions are contained in Figure C1.

The time span during which these postulated described strikes occur is from the present to after sale 47, through the period leading to peak production in tracts leased in sale 47. It is assumed that in this period tracts in the strike areas which are currently leased but not yet explored or in production will not expire.

The number of strike areas described for each of the block locations described in Appendix B are as follows (See Map C1):

| | |
|---|---|
| 6 | High Island East Addition South Extension |
| 4 | High Island South Addition |
| 2 | Galveston South Addition |
| 2 | Brazos South Addition |
| 1 | Matagorda Island |
| 1 | Mustang Island East Addition |
| 1 | Mustang Island |
| 1 | South Padre Island East Addition |
| 1 | South Padre Island |
| 2 | Bay City & Garden Banks |

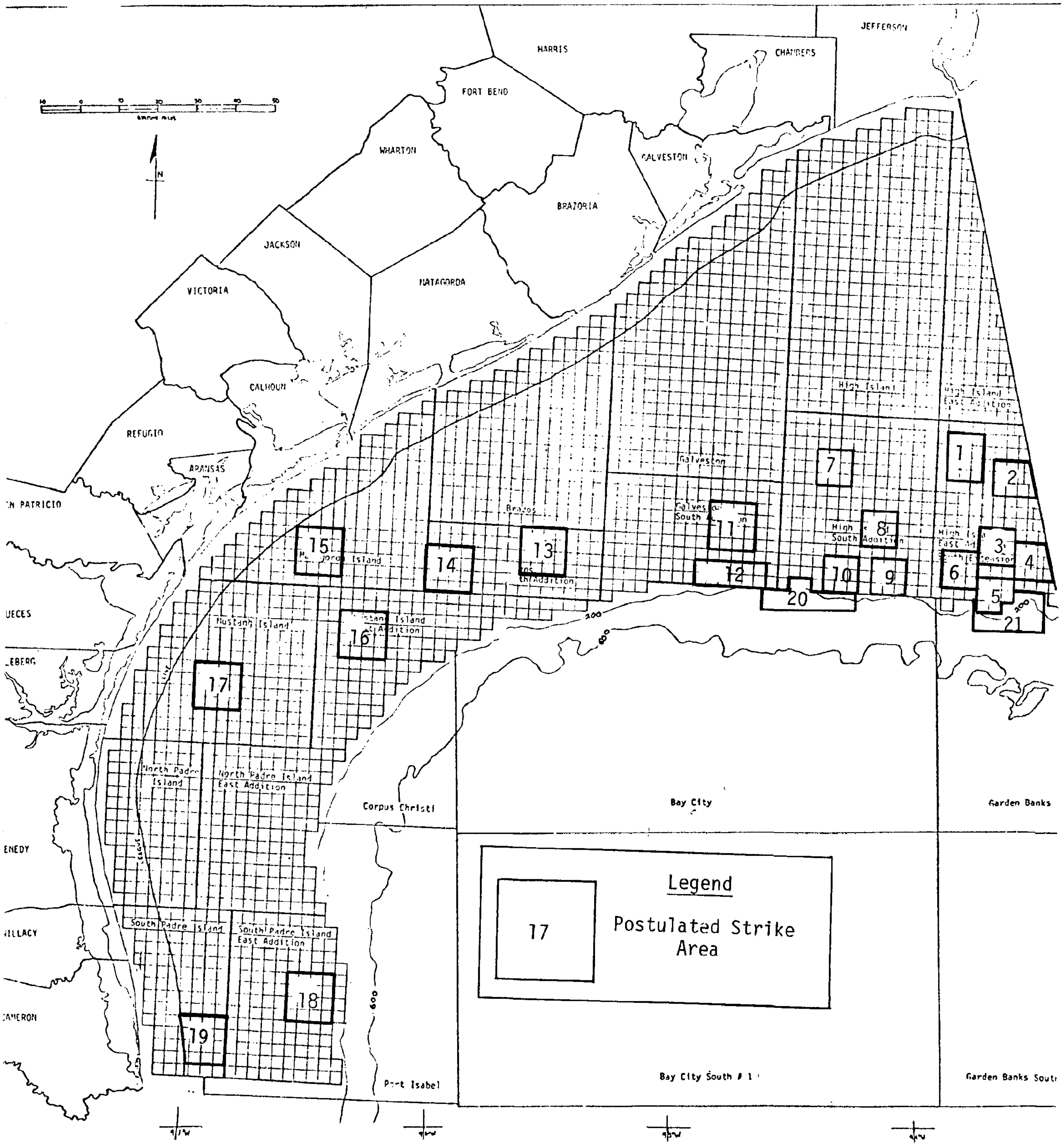
This distribution follows the trend in percentage of tracts leased in each of the blocks (see Figure C2). This distribution of strike areas assumes that through sale 47, continued emphasis will follow past leasing and exploratory interest, concentrating first in the High Island South Addition and East Addition South Extension blocks. It also assumes that the oil industry approach will be to further evaluate leased but unexplored tracts before major new leases are sought.

Figure C1. Descriptions of Hypothesized Strikes in the Texas Federal OCS

| Strike Area | | # Tracts | # Tracts Leased | # Tracts Offered 44 | # Tracts Offered 47 | # Tracts Leased From 44 | # Tracts Leased From 47 | # Tracts Explored From 44 | # Tracts Explored From 47 | # Tracts Explored From Old Lease | # Tracts Developed From 44 | # Tracts Developed From 47 | # Tracts Developed From Old Leases | # Tracts Put Into Production From 44 | # Tracts Put Into Production From 47 | # Tracts Put Into Production From Old Leased | Annual Amount of Production From Each Producing Tract Million MCF Gas Thousand Bbls oil Future Activity | Old Activity | Producing Trend | Depth Range (Feet) | Water Depth Meters |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High Island East Addition South Extension | 1 | 12 | 5(42%) | 1 | 4 | 1(100%) | 1(25%) | 1(100%) | 1(100%) | 2(40%) | 1(100%) | 1(100%) | 1(50%) | 1(100%) | 1(100%) | 1(100%) | 3@ 27G 154Ø | 1@ 30G 165Ø | Plio-Pleistocene | 4,000 - 15,000 | 45-60 |
| | 2 | 12 | 3(25%) | 1 | 6 | 0-- | 3(50%) | -- | 2(67%) | 2(67%) | -- | 1(50%) | 0-- | -- | 1(100%) | -- | 1@ 22G 100Ø | 1@ 18G 100Ø | Pleistocene | 4,000 - 9,500 | 55-65 |
| | 3 | 9 | 3(33%) | 0 | 6 | 0-- | 2(33%) | -- | 2(100%) | 1(33%) | -- | 1(50%) | 0-- | -- | 1(100%) | -- | 1@ 25G | -- | Pleistocene | 4,000 - 10,500 | 75-100 |
| | 4 | 11 | 7(64%) | 0 | 2 | 0-- | 2(100%) | -- | 2(100%) | 3(43%) | -- | 1(50%) | 2(67%) | -- | 1(100%) | 2(100%) | 3@ 29G | 3@ 30G | Pleistocene | 5,000 - 11,000 | 80-150 |
| | 5 | 8 | 3(38%) | 0 | 1 | 0-- | 1(100%) | -- | 1(100%) | 1(33%) | -- | 0(0%) | 1(100%) | -- | -- | 1(100%) | 1@ 15G | -- | Pleistocene | 5,000 - 11,500 | 150-200 |
| | 6 | 9 | 3(33%) | 0 | 3 | 0-- | 2(67%) | -- | 2(100%) | 3(100%) | -- | 1(50%) | 1(33%) | -- | 1(100%) | 1(100%) | 2@ 19G | -- | Pleistocene | 5,000 - 11,000 | 80-150 |
| | Total | 61 | 24(39%) | 2 | 22 | 1(50%) | 11(50%) | 1(100%) | 10(91%) | 11(46%) | 1(100%) | 5(50%) | 5(45%) | 1(100%) | 5(100%) | 5(100%) | 353G 562Ø | 294G 265Ø | | | |
| High Island South Addition | 7 | 9 | 0-- | 0 | 3 | 0-- | 1(33%) | -- | 1(100%) | 0-- | -- | 1(100%) | 0-- | -- | 1(100%) | -- | 1@ 18G 300Ø | -- | Plio-Pleistocene | 6,000 - 14,000 | 45-55 |
| | 8 | 9 | 2(22%) | 0 | 4 | 0-- | 2(50%) | -- | 1(50%) | 1(50%) | -- | 1(100%) | 1(100%) | -- | 1(100%) | 1(100%) | 2@ 22G 110Ø | -- | Pleistocene | 5,000 - 9,000 | 60-80 |
| | 9 | 9 | 3(33%) | 0 | 5 | 0-- | 3(60%) | -- | 2(67%) | 1(33%) | -- | 1(50%) | 1(100%) | -- | 1(100%) | 1(100%) | 1@ 27G | 1@ 28G | Pleistocene | 5,000 - 10,000 | 85-200 |
| | 10 | 9 | 2(22%) | 0 | 2 | 0-- | 1(50%) | -- | 1(100%) | 1(50%) | -- | 1(100%) | 0-- | -- | 1(100%) | -- | 1@ 23G | -- | Pleistocene | 5,000 - 9,000 | 80-190 |
| | Total | 36 | 7(19%) | 0 | 14 | 0-- | 7(50%) | -- | 5(71%) | 3(43%) | -- | 4(80%) | 2(67%) | -- | 4(100%) | 2(100%) | 90G 410Ø | 50G 110Ø | | | |
| Galveston South Addition | 11 | 16 | 1(6%) | 0 | 4 | 0-- | 2(50%) | -- | 1(50%) | 0-- | -- | 1(100%) | 0-- | -- | 1(100%) | -- | 1@ 20G | 1@ 21G | Pleistocene | 4,000 - 6,000 | 50-80 |
| | 12 | 12 | 4(33%) | 0 | 5 | 0-- | 3(60%) | -- | 2(67%) | 2(50%) | -- | 1(50%) | 1(50%) | -- | 1(100%) | 1(100%) | 1@ 21G 95Ø | 1@ 25G 100Ø | Pleistocene | 4,000 - 9,000 | 90-175 |
| | Total | 28 | 5(18%) | 0 | 9 | 0-- | 5(56%) | -- | 3(60%) | 2(40%) | -- | 2(67%) | 1(50%) | -- | 2(100%) | 1(100%) | 41G 95Ø | 46G 100Ø | | | |
| Brazos South Addition | 13 | 16 | 2(13%) | 0 | 4 | 0-- | 3(75%) | -- | 2(67%) | 2(100%) | -- | 2(100%) | 0-- | -- | 2(100%) | -- | 1@ 29G 23G | -- | Pleistocene Mio-Pliocene | 3,500 - 4,500 7,000 - 12,500 | 50-75 |
| | 14 | 16 | 6(38%) | 1 | 5 | 1 | 3(60%) | 1(100%) | 3(100%) | 2(33%) | 1(100%) | 2(67%) | 1(50%) | 1(100%) | 2(100%) | 1(100%) | 1@ 29G 1@ 19G 1@ 22G | 3@ 24G | Upper Miocene | 8,000 - 13,000 | 45-65 |
| | Total | 32 | 8(25%) | 1 | 9 | 1(100%) | 6(67%) | 1(100%) | 5(83%) | 5(63%) | 1(100%) | 4(80%) | 1(20%) | 1(100%) | 4(100%) | 1(100%) | 144G | 72G | | | |
| Matagorda Island | 15 | 16 | 4(25%) | 0 | 3 | 0-- | 1(33%) | -- | 1(100%) | 3(75%) | -- | 1(100%) | 2(67%) | -- | 1(100%) | 2(100%) | 3@ 13G | 1@ 10G | Lower Miocene | 6,000 - 10,000 | 25-45 |
| Mustang Island East Addition | 16 | 16 | 6(38%) | 0 | 3 | 0-- | 1(33%) | -- | 1(100%) | 4(67%) | -- | 0-- | 2(50%) | -- | -- | 2(100%) | 2@ 22G | -- | Upper Miocene | 6,000 - 12,000 | 60-100 |
| Mustang Island | 17 | 16 | 2(13%) | 0 | 4 | 0-- | 3(75%) | -- | 2(67%) | 1(50%) | -- | 1(50%) | 1(100%) | -- | 1(100%) | 1(100%) | 1@ 17G 1@ 12G 90Ø | -- | Lower Miocene | 5,000 - 10,000 | 30-50 |
| South Padre Island East Addition | 18 | 16 | 5(31%) | 0 | 5 | 0-- | 3(60%) | -- | 2(67%) | 4(80%) | -- | 1(50%) | 2(50%) | -- | 1(100%) | 2(100%) | 2@ 14G 95Ø 1@ 200Ø | -- | Plio-Pleistocene | 2,000 - 6,000 | 60-80 |
| South Padre Island | 19 | 16 | 2(13%) | 0 | 4 | 0-- | 1(25%) | -- | 1(100%) | 2(100%) | -- | 1(100%) | 1(50%) | -- | 1(100%) | 1(100%) | 2@ 22G 125Ø | -- | Mio-Pliocene | 3,000 - 12,000 | 30-45 |
| Deep (Bay City) | 20 | 20 | 7(35%) | 0 | 13 | 0-- | 8(62%) | -- | 5(63%) | 3(43%) | -- | 3(60%) | 2(67%) | -- | 1(33%) | 2(100%) | 3@ 30G | 1@ 31G | Pleistocene | 5,000 - 10,000 | 150-300 |
| Deep (Garden Banks) | 21 | 20 | 0-- | - | 13 | 0-- | 8(62%) | -- | 5(63%) | -- | -- | 3(60%) | -- | -- | 3(100%) | -- | 3@ 35G | -- | Pleistocene | 5,000 - 11,500 | 190-375 |
| GRAND TOTAL | | 277 | 70(25%) | 3 | 99 | 2(67%) | 54(54%) | 2(100%) | 40(74%) | 38(54%) | 2(100%) | 25(63%) | 19(50%) | 2(100%) | 23(92%) | 19(100%) | 1,057G 1,687Ø | 453G 365Ø | | | |

GT = 1,510G 2,052Ø

MAP C1



JEFFERSON
HARRIS
CHAMBERS
FORT BEND
WHARTON
GALVESTON
BRAZORIA
JACKSON
MATAGORDA
VICTORIA
CALHOUN
REFUGIO
ARANSAS
N
High Island
High Island East Addition
Galveston
Galveston South Addition
High South Addition
High Island East Addition
East Extension
Brazos
Brazos South Addition
Matagorda Island
Mustang Island
Mustang Island East Addition
North Padre Island
North Padre Island East Addition
South Padre Island
South Padre Island East Addition
Corpus Christi
Bay City
Garden Banks
Port Isabel
Bay City South # 1
Garden Banks South
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
200
600
Legend
17
Postulated Strike Area

Figure C2. Federal OCS Block Activity Characteristics

| Block | (1) Total No. of Tracts | (2) No. Tracts Leased | (3) Tracts Leased In Sale 41/% of (2) | (4) Tracts Offered In Sale 44 | (5) Tracts with Current Exploration /Percent of (2) | (6) Tracts with Post Exploration /Percent of (2) | (7) Tracts Proven Producible/ Percent of (6) | (8) Tracts with Platforms approved or set/Percent of (7) |
|---|---|---|---|---|---|---|---|---|
| High Island East Addition South Extension | 145 | 80**(55%) | 4 (3%) | 2 | 2 (1.4%) | 53 (69%) | 13 (25%) | 7 (54%) |
| High Island South Addition | 184 | 84 (46%) | 4 (5%) | 0 | 3 (4%) | 46 (58%) | 14 (30%) | 6 (43%) |
| Galveston South Addition | 135 | 20 (15%) | 0 -- | 0 | 1 (5%) | 8 (40%) | 1 (13%) | 0 -- |
| Brazos South Addition | 90 | 10* (11%) | 0 -- | 1 | 0 -- | 8 (50%) | 3 (38%) | 1 (33%) |
| Matagorda Island | 120 | 21**(18%) | 2 (9.5%) | 0 | 1 (5%) | 3 (18%) | 0 -- | 0 -- |
| Mustang Island East Addition | 143 | 21 (15%) | 0 -- | 0 | 1 (5%) | 1 (5%) | 0 -- | 0 -- |
| Mustang Island | 163 | 40 (25%) | 1 (2.5%) | 0 | 0 -- | 2 (5%) | 1 (50%) | 0 -- |
| So. Padre Island East Addition | 132 | 12 (9%) | 0 -- | 0 | - -- | -- -- | - -- | - -- |
| So. Padre Island | 67 | 5 (7%) | 0 -- | 0 | - -- | -- -- | - -- | - -- |
| Deep(Bay City) | N.A. | 13 N.A. | 0 -- | 0 | 2 (15%) | 2 (15%) | 1 (50%) | 0 -- |

* Does not include 5 expired leases which had been explored

** Does not include 1 expired lease which had been explored

The location of strike areas is based on past experience of recent leasing trends, proven exploration, and on the basis of favorable geologic conditions. The primary geologic indicator used here is descriptions of the extent of sediment accumulation with favorable petroleum potential. The strike areas therefore bound or include current leases. (See Attachment BI of Appendix B.)

Different sized strike areas (9, 12, and 16 tract-sizes) represent different degrees of likelihood that a petroleum field will be encountered in the area. As such, the selection of strike area size is largely determined by the extent of past leasing and exploration in a block.

The postulated values for items 1-6 described above are guided by the reasonable ranges for these items developed in Appendix B as applied to the whole Texas federal OCS (see Figure B1: Appendix B). The values for these items given here may exceed either limit of those reasonable ranges, as they are here described for small strike areas, and are therefore not subject to an averaging effect in analyzing a larger area. The summation and average of all the strike area strike characteristics, however, does approximate the reasonable ranges previously described (see Figure B1: Appendix B).

The number of tracts put into production as a percent of developed tracts resulting from sale 47 in the Bay City Deep Gulf area (strike area no.20) is not the prescribed 100%. This deviation is incorporated to retain, in the development of scenarios, the option of not allocating to that location production equipment throughout the time span assumed in this series of strike descriptions.

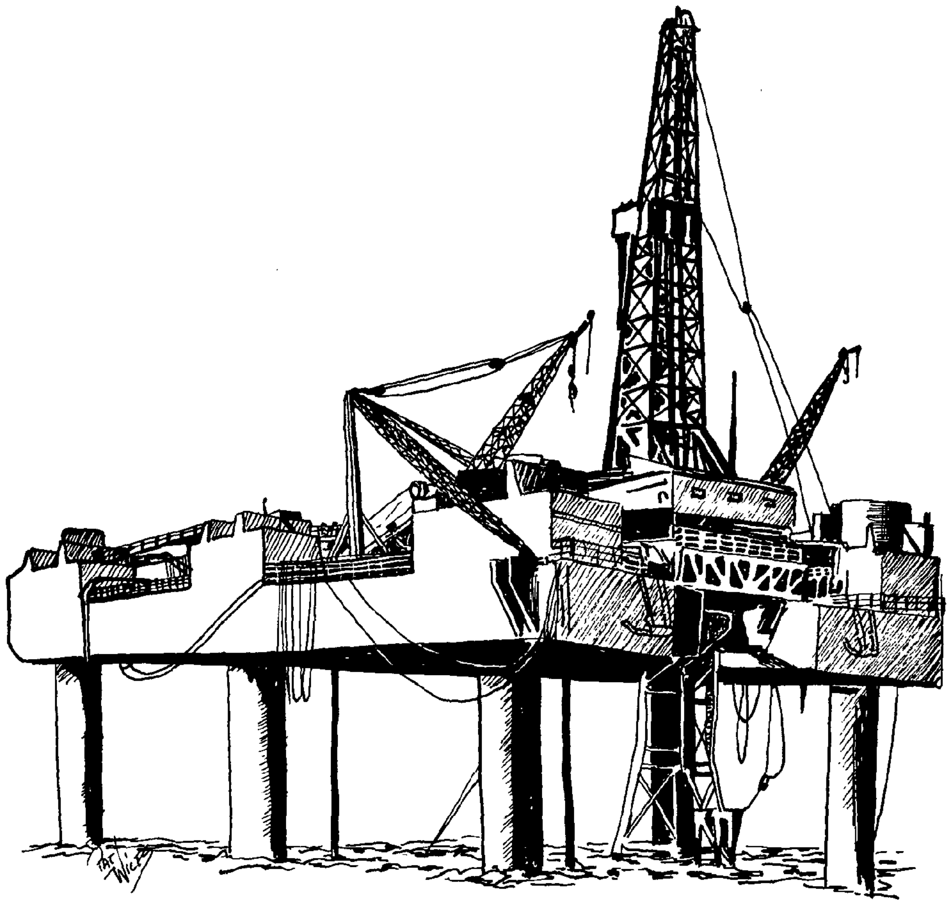
Two categories are given for the amount of production from each producing tract. Future activity includes production resulting from sales 44 and 47, as well as from currently leased tracts not yet in the exploration to production sequence. Old activity includes production from tracts included in the strike area which are currently being explored, which have shut-in exploratory wells, or have platforms approved or set in for production to commence in the near future.

The amount of production is based on the reasonable ranges of production described in Appendix B and on tract-specific production history from the Texas Railroad Commission, which was used in developing the reasonable production ranges. The production characteristics from the Pleistocene of the southern High Island blocks is assumed to be similar to historic production levels from the lower Miocene of High Island block tracts near the three-league line. Successful exploratory wells indicate that gas production will predominate over oil production near the shelf edge. Production levels in the Brazos South Addition block, the Matagorda Island block, and the Mustang Island block are postulated to continue the trend from the northeast, yet not at so high a level of production. Production estimates from the 2 South Padre blocks are very speculative yet reasonable. Just as there is little data to support the estimates, there is little to refute them.

Drilling depth range to producing trend and water depth are read from the structure contour map of the producing trends' base (Maps B3 to B5: Appendix B) and from BLM maps. The range of drilling depth includes the minimum and maximum depth at which the strike will be encountered in the given trend.

# APPENDIX D

# INDUSTRY PRACTICES



# INDUSTRY PRACTICES

What follows is a description of requirements, scheduling, and other characteristics of the development patterns associated with any given postulated strike in the Texas federal OCS. Thus, the information contained herein can be thought of as either time scheduling of OCS development activities or type and amount of equipment associated with each step in OCS oil and gas development.

The first section below presents time sceduling information, the second section presents equipment information, and the third, (Figure D1) combines the first two in a comprehensive display of time and equipment requirements. The steps of OCS development examined in each section include:

1. Pre-lease sale seismographic or other exploration;
2. The lease sale;
3. Exploratory drilling;
4. Development drilling;
5. Production;
6. Transportation and storage; and
7. Operations and maintenance.

In addition, a brief analysis of the sensitivity of private investors' OCS development decisions to government policy variables is presented. Such sensitivity can, of course, greatly affect the timing of OCS exploration, development and production.

## Time Scheduling

The information contained in this section was derived primarily from six sources: Energy Under the Oceans, Kash, et al (1973), Effects of Off shore Oil and Natural Gas Development on the Coastal Zone, a study for the Ad Hoc Select Committee on Outer Continental Shelf, prepared by the Library of Congress Congressional Research Service (1976); Energy Perspectives, U.S. Dept. of Interior(1975); Leasing and Management of Energy Resources on the Outer Continental Shelf, U. S. Dept. of Interior (1974); information derived from U.S.G.S. computer printouts detailing OCS activity specific to the Texas federal OCS (1976); and the BLM Leasing Schedule (January, 1977). This section is intended to be accompanied by Figure D1.

1. Pre-lease sale exploration. Most sources agree that presale exploration takes place over an indeterminate period of time. Kash hypothesizes a nine-month period, but acknowledges that such activity could last five years and longer. The Ad Hoc Committee report simply calls it an "indeterminate" period of time.

2. Lease sale. For purposes of this analysis, "lease sale" includes review of the DEIS, review of the FEIS, the sale day, review of the bids, and letting of leases.

The DEIS must be released at least 90 days before the sale date. While that can be seen as the required time period, the Ad Hoc Committee report estimates that the DEIS is released 9 months in advance of the sale, and BLM itself estimates 5-7 months in advance of Gulf of Mexico sales.

The FEIS must be released at least 30 days before the sale. Again, this can be seen as the required period; the Ad Hoc Committee report estimates 60 days, and BLM estimates 60-120 days.

The least sale itself, of course, takes place in one day. BLM then has 30 days to decide to reject or accept bids. The lease is effective on the first of the month following acceptance of the bid. Thus, 30 days is the time period involved.

3. Exploratory drilling. After a lease bid has been accepted, the developer submits an exploratory drilling plan to USGS and applies for a permit to drill. USGS has 30 days to decide if an EIS is required, but the entire process of approving a plan and granting a drilling permit could take, according to the Ad Hoc Committee report, 5 to 27 months. The actual exploratory drilling itself takes place in 3 months according to Kash, in 1 to 6 months according to the Ad Hoc Committee report, and in 1 to 3 months according to Energy Perspectives. Analysis of 71 cases (from 1973 to 1976) printed out in the USGS computer runs indicates that the average length of time from the effective date of the lease until completion of the first exploratory well has been 9.5 months. (The longest case was 29 months; the shortest was one month.) Leasing and Management estimates the same period to be 1.5 to 4.5 years. Thus, the total time from the effective date of the lease until completion of the first exploratory well can be, when all the foregoing estimates are considered, 3 to 54 months. It must be remembered, however, that that range of time in the Texas federal OCS in recent years has been 1 to 29 months and that 9.5 months is the average.

4. Development drilling. Time estimates for development drilling are of two types: those that provide estimates of the period of time between the effective date of the lease and installation of the first development platform and thus first production; and those that estimate the length of time that development drilling continues. Kash

estimates that as few as three months elapse between leasing and beginning of development drilling; the Ad Hoc Committee report estimates 20 to 51 months; Leasing and Management estimates 2.5 to 6.5 years until first production from a platform; and Energy Perspectives estimates 27 to 54 months. The USGS printouts for the Texas Federal OCS activities indicate that in 27 cases (from 1957 to 1976) the average length of time from effective date of the lease until installation of a development platform has been 52.3 months. (The longest time was 295 months; the shortest was nine months.)

The length of time that development drilling continues is usually defined as the time required to reach significant production; that is, until production equipment, gathering systems, and/or pipelines are connected to OCS wells. Kash estimates that period to be 17 months; the Ad Hoc Committee report estimates it to be 15 to 27 months; and Energy Perspectives estimates it to be 9 to 33 months.

5. Production. Production is normally defined as that period of time, after production equipment is installed on a platform, that the well or wells continue to produce. It is widely agreed, needless to say, that that is an indeterminate time. Estimates are sometimes given, however, for the period of time between the lease sale and commencement of commercial production in permanent production facilities. Kash, for example, estimates that time to be 40 months; the Ad Hoc Committee report estimates it to be 126 months. The latter figure may be an overestimation in that it considers all OCS drilling in every location. Other estimates attempt to isolate the length of time from the effective date of the lease until peak production is reached. Leasing and Management estimates 84 to 168 months; Energy Perspectives estimates 52 to 102 months in the Gulf of Mexico.

6. Transportation and storage. Kash estimates that 98% of all OCS production in the Gulf of Mexico is transported to shore by pipeline; barges or tankers are sometime used as temporary means of transportation during exploration, development, or for low-yield fields. For this reason, emphasis in this analysis is on pipeline transportation.

Two sources provide estimates for the length of time between effective date of the lease and the pipeline permitting and construction process. The Ad Hoc Committee report estimates that time to be 45 to an indeterminate number of months. Energy Perspectives estimates that in the Gulf of Mexico, pipelines are constructed and connected to OCS wells within 36 to 60 months after the lease becomes effective. Kash contends that offshore storage will not be necessary for the U.S. OCS, at least in the foreseeable future. If additional onshore storage is required to accomodate the production from a new OCS discovery, it is reasonable to assume that construction of such facilities would coincide reasonably well with construction of pipeline facitities.

One further bit of evidence is available. The earliest date of lease for any tract in the High Island South Addition or High Island East Addition South Extension Areas was August, 1973. A large pipeline to serve that area was approved in May, 1976. Assuming a 12-month construction period, the length of time between effective date of lease and construction of the pipeline would be 46 months.

7. Operations and maintenance. These activities continue over the life of the field and are of indeterminate length.

## Type and Amount of Required Equipment

The information contained in this section was derived primarily from four sources: Energy Under the Oceans, Kash, et al (1973); Leasing and Management of Energy Resources on the Outer Continental Shelf, U.S. Dept. of Interior (1974); information derived from U.S.G.S. computer printouts detailing OCS activity specific to the Texas federal OCS (1976); and Mid-Atlantic Regional Study, Woodward-Clyde Consultants (1975). The following items are contained in this section:

1. Equipment involved in seismographic or other pre-lease sale exploration;
2. Number and type of exploratory wells per explored tract;
3. Number and type of exploratory wells per rig/per year;
4. Number of platforms per developed tract (included is a short description of a development platform);
5. Number of development wells per platform;
6. Number of development wells per platform/per year;
7. Number of platforms per producing tract (included is a short description of a production platform);
8. Number of production wells per platform;
9. Equipment involved in transportation and storage; and
10. Equipment involved in operations and maintenance.

It should be noted that the most widely referred-to study for equipment information (not only in this analysis but also by previous impact studies) is the Kash work. Its section on "Development of OCS Resources" is excellent. The best information in regards to amount of equipment entailed in each OCS development phase are the USGS printouts of Texas federal OCS activity. Woodward-Clyde's (W/C) study provided estimates for the amount of equipment needed for future development of the Mid-Atlantic OCS, but it is important to remember that the situations in a frontier area such as the Atlantic are undoubtedly very different from the Gulf of Mexico in many important aspects. This section is intended to be accompanied by Figure D1.

1. The equipment involved in pre-lease sale exploration, according to Kash, usually involves air- or ship-borne passive measurement, seismic surveying, or bottom sampling and coring.

Air- or ship-borne passive measurement involves the reading of "changes in the earth's magnetic field, local variations in the earth's gravity, and the existence of natural oil seeps." In addition, gravimetry (measurement of gravitational fields or density) is used in the Gulf of Mexico to locate salt dome structures.

Seismic surveying from a ship is by far the most widely used pre-lease sale exploratory method. It involves the generation of sound waves which are bounced off the seabed's geologic strata. The echos are picked up by ship-borne instruments, and cross-sections and three-dimensional reproductions of the underlying geologic structures can be constructed. Explosives were for many years used as a source of sound waves; they have been replaced by contained gas explosions or electronic vibrators.

On occasion, USGS will authorize bottom sampling or coring to a maximum depth of 1000 ft. Such authorization is only granted if seismic data reveals a need for the additional information which bottom sampling or coring can provide.

Because pre-lease sale exploration takes place over an indeterminate length of time, it is difficult to know or to estimate how many exploratory ships would be involved in the exploration of a single tract. It is relatively safe to assume, however, that no more than three ships (even if bottom sampling and/or coring were authorized) would be required to explore one tract.

2. Kash explains that four types of rigs are currently being used for exploratory drilling: barges, drill ships, jack-ups, and semi-submersibles.

Barges are much like drill ships and can be used to drill in water up to 600 feet deep but are generally used only in shallow water. Drill ships can drill in up to 3000 feet of water and are often equipped with a dynamic positioning system which detects and compensates for the water's movement, thus enabling the ship to maintain a stationary position.

Jack-up rigs, with legs in the "up" position, can float and be towed into position. Once in position, the legs are extended and the platform is elevated above the water; a bottom-standing exploratory platform is the result. Jack-ups can drill in water depths up to 350 feet.

Semi-submersibles have a platform deck supported by columns which are connected to underwater displacement hulls. The hulls can be flooded on site to anchor the rig to the seabed. They can operate in up to 2000 feet of water.

Jack-up rigs seem the most likely to be used in the Texas federal OCS except in water over 250 feet where semi-submersibles will probably be used.

USGS computer printouts indicate that in 230 cases from 1947 through 1975, the average number of exploratory wells per explored tract in the Texas federal OCS has been 2.0. (The most has been 9; the least has been one.)

It is interesting to note that the W/C study used the same figure: two exploratory wells per explored tract.

3. Number and type of exploratory wells per rig/per year. The type of equipment involved in this item is the same as that for Item 2 above (barges, drill ships, jack-ups, or semi-submersibles). USGS printouts indicate that in 131 cases from 1968 to 1976 the average number of exploratory wells completed in a 12-month period was 1.9. (242 wells completed in 1535 drilling months.) The figure used in the W/C study was 4.

4. After commercial accumulations of oil or gas are found to exist in any given OCS tract, field development will begin. Field development entails the use of fixed platforms and/or underwater completions, sometimes known as subsea completions.

Fixed platforms are permanently attached to the seabed by steel pilings and support one or more decks on which drilling or production equipment or quarters are mounted. Fixed platforms operate in water depths up to 550 feet although the potential water depth is probably greater. From these platforms, development wells are drilled in a gradual curve by "controlled directional drilling." Such drilling makes it possible to drill as many as 60 wells from one platform.

Underwater completions involve the placement of wellheads directly on the seabed rather than on platforms. The production from underwater completions is pumped either to a nearby fixed platform or to shore.

USGS printouts indicate that in 89 cases from 1959 to 1976 (including approximately 25 proposed platform cases) the average number of platforms per developed tract (including both development platforms and production platforms) is 1.6. (The most platforms in one tract is 9; the least is one; there are a total of 89 platforms in 56 developed tracts.) The W/C study estimated 3 platforms per developed tract.

5. As Item 4 above points out, one platform is capable of drilling many development wells. USGS printouts indicate that in 53 cases from 1959 to 1976, the average number of development wells per platform in the Texas federal OCS is 3.2. (The most is 17; the least is 0.) The W/C study estimated 2 development rigs, each able to drill 8 wells per year.

6. Number of development wells per platform/per year. USGS printouts indicate that in eight cases from 1968 to 1976, the average

number of development wells completed in a 12-month period is 4.6. (31 wells in 80 drilling months.) The W/C study estimated eight development wells per platform/per year.

7. A production platform may be distinguished from a development platform by the type of equipment mounted on the platform. As the development wells on each platform are completed, the development rigs are removed to other platforms, and production equipment is brought in. Production equipment is designed to separate sand, water, gas, and oil and to regulate the flow of oil and gas. The system of valves used to control such flow is known as a "Christmas tree."

USGS printouts indicate that in 15 cases from 1955 through 1975, the average number of platforms per production tract (tracts outfitted with production equipment) in the Texas federal OCS is 1.2. (The most is 2; the least is one.) The W/C study estimated 3 platforms per producing tracts.

8. USGS printouts indicate that for 18 cases from 1955 through 1975, the average number of wells per production platform (platform outfitted with production equipment) in the Texas federal OCS is 5.4. (The most is 17; the least is 0.) The W/C study estimated 24 wells per production platform.

It must be noted that "producing" platforms and platforms outfitted with production equipment are not necesarily the same. Some platforms are producing but are not outfitted with production equipment; they pump their production to platforms which are so equipped. For example, USGS printouts reveal 32 producing platforms in the Texas federal OCS, 18 (56%) of which have production equipment. Thus, the number of wells per producing platform is different than the number of wells per production platform. We have already seen that the average number of wells per production platform in the Texas federal OCS is 5.4. On the other hand, USGS printouts indicate that for 32 cases from 1955 through 1975, the average number of wells per producing platform in the Texas federal OCS is 4.0. ("Producing" platforms, of course, include "production" platforms.) The fact that one production platform can serve several "producing" platforms is relevant in the completion of any OCS impact study.

In addition, the number of wells per producing or production platform - derived from USGS printouts detailing current activity - dramatically underestimates the potential number of wells per platform. The most modern platforms, particularly when operating in deep water, are capable of drilling up to 50 wells. Thus, the number of wells per platform is to some extent dependent on the sophistication of the platform and the depth of water in which the platform is situated. In the Texas federal OCS, the number of wells per platform could easily reach twenty-five.

9. As previously mentioned, nearly all transportation of OCS oil and gas production to onshore facilities is by pipeline. Kash tells us that there are three primary techniques of laying pipeline offshore. The most common technique is the lay barge. Sections of the pipeline are welded together on the barge and released as the barge moves forward.

The second method is a reel barge. Sections of pipe are welded together onshore, wound on to a reel on the barge, and released directly from the reel. This technique is limited to 4 to 10 inch diameter pipes.

The third technique is to pull pipe from fabricating facilities onshore into the water. This technique is limited by the length of pipeline which can be pulled (2 to 4 miles is maximum). Pipeline can also be assembled onshore, floated out to the site, then sunk and welded. This last method requires relatively calm seas and costly diving activities.

Pipelines must, by law, be buried in the seabed when they are laid in under 200 feet of water. They are usually buried in a trench formed by a high-pressure water jet.

Storage facilities can be land-based or offshore. Kash expects no pressing need for offshore storage in U.S. waters in the foreseeable future. Onshore storage is normally associated with refineries or ports.

The extent to which additional pipeline, pipeline facilities, and storage facilities will be required by future OCS oil and gas development will undoubtedly be a direct result of the amount by which such production exceeds the current capacity to transport or store it.

10. It is reasonable to assume that the type and amount of equipment needed for operation and maintenance of producing or production platforms will be essentially the same as those required for the production phase of OCS activities, described in Items 7 and 8 above.

It has already been noted that the extent and rate of OCS oil and gas development can be significantly impacted by private investors' sensitivity to government policy variables. Among those variables are control of gas prices, the depletion allowance, environmental regulations, and many more. Appendix B notes that one of this study's assumptions is a relatively stable governmental policy context. That assumption notwithstanding, it remains necessary to point out that substantive policy changes could affect private investment decisions and, thus, conclusions reached by RPC in the conduct of its study.

It is also important to determine, given RPC's "straight line" assumptions concerning pricing, supply, demand, production, and governmental policy (as outlined in Appendix B), if adequate OCS development investment funds are expected to be available in the future. Perhaps the best source of such information is the Project Independence Report (PIR), published by the Federal Energy Administration (FEA) in November, 1974.

The PIR projected Gross National Product (GNP) and business-fixed investment to 1985. The traditional ratios of investments in energy to GNP and business-fixed investment were used to calculate future energy investment levels. Since World War II, energy investment has averaged approximately 23% of total business-fixed investment. When that 23% is applied to the projected total investment until 1985, $435 billion (in 1973 dollars) is the result: the total amount of energy investment from 1975 to 1985. That figure was then compared to estimates of the amount of energy investment funds required through 1985; those estimates range from $367 to $457 billion. FEA's estimate is $367 billion; thus, PIR concludes that adequate investment funds will be available. The Federal Power Commission estimated that $380 billion will be required, and Arthur D. Little, Inc. estimated $396; both estimates would be attainable using FEA's energy-investment-fund-available figure of $435.

The National Academy of Engineering, on the other hand, estimated that $457 billion will be needed; such a requirement would surpass FEA's estimate of energy investment funds available. To attain the $457 billion mark, investment in energy from 1975 through 1985 would have to equal 24.2%, not 23% of total business fixed investment.

The PIR continues by noting that "...while there may be enough investment resources to support the projected energy investment in the aggregate, specific sectors of the energy industry may not be able to maintain their historical share of investment..." Thus, the PIR analyzed those individual sectors; among them was the oil and gas sector.

"The oil and gas industries appear to have no financial problem over the 1975 to 1985 period", according to PIR,"...the oil industry will be able to finance internally all of its investment requirements and still have additional funds to assist other energy projects outside the oil and gas industry."

The PIR projections assume "a stable economy, a real annual growth rate of 4%, an inflation rate falling to about 4.5%, and an unemployment rate remaining around 5%."

Figure D1

ACTIVITY

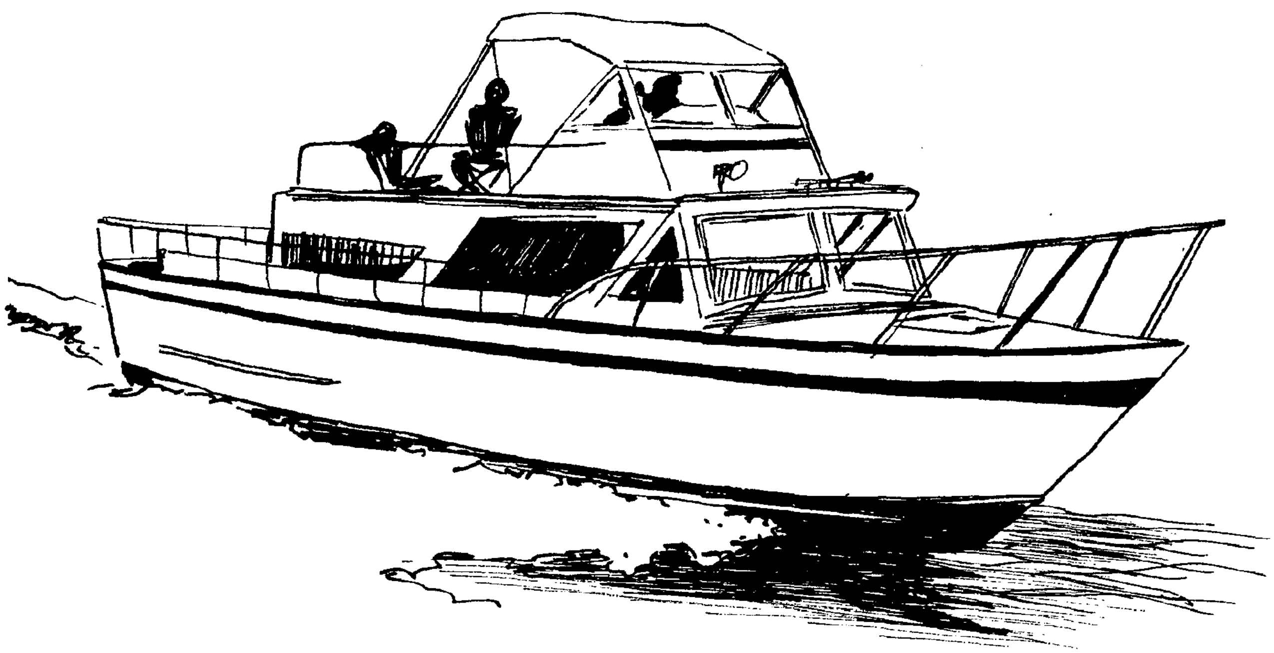
| | Pre-Lease Sale Exploration | Review of DEIS | Review of FEIS | Sale, Review of Bids, and Letting of Leases | Effective Date of Lease Until Exploratory Drilling Begun | Exploratory Drilling To Completion (either dry hole or discovery) | Effective Date of the Lease Until Development Platform Installed (first production) | Development Drilling Continues | Effective Date of the Lease Until Commercial Production/ Permanent Production Facilities | Effective Date of the Lease Until Peak Production | Effective Date of the Lease Until Pipeline Construction | Operations and Maintenance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time Period Required (Source) | Indeterminate (Ad Hoc)<br>9 to 60 Months or Longer (Kash) | 3 Months Before Sale is Required By Law (Kash)<br>9 Months Before Sale (Ad Hoc)<br>5-7 Months Before Sale (BLM) | 1 Month Before Sale is Required (Kash)<br>2 Months Before Sale (Ad Hoc)<br>2 to 4 Months Before Sale (BLM) | 1 Month (Kash and Ad Hoc) | 5-27 Months (Ad Hoc)<br>At Least 2 Months (Kash)<br>9.5 Months-(USGS)<br>18 to 54 Months (Leasing) | 3 Months (Kash)<br>1-6 Months (Ad Hoc)<br>1-3 Months (Energy) | 3 Months (Kash)<br>20-51 Mos. (Ad Hoc)<br>48-132 Mos. (Leasing)<br>27-54 Mos. (Energy)<br>52.3 Mos. (USGS) | 17 Months (Kash)<br>15-27 Mos. (Ad Hoc)<br>9-33 Mos. (Energy) | 40 Months (Kash)<br>126 Months (Ad Hoc) | 84-186 Mos. (Leasing)<br>52-102 Mos. (Energy) | 45 Mos. to Indeterminate(Ad Hoc)<br>36-60 Mos. (Energy) | Indeterminate |
| EQUIPMENT:<br>Type (Source) | Air or Ship Borne Passive measurement/ seismic surveying/bottom sampling. (Kash) | N/A | N/A | N/A | N/A | Barges/ Ships/ Jack-Ups/ Semi-Submersibles (Kash) | Fixed Platforms and/or Underwater Completions (Kash) | | Fixed Platforms Equipped With Production Equipment or Producing Platforms without Production Equipment (Kash) | | Lay Barge; Reel Barge; Pulling; Floating (Kash) | |
| Number (Source) | Max. of three ships (RPC esti.) | N/A | N/A | N/A | N/A | 2 per explored tract; 1.9 per rig/ per year (USGS) | 1.6 Fixed Platforms per Developed Tract; 3.2 Development Wells Per Platform; 4.6 Development Wells per Platform Per Year. (USGS) Potentially, 25 wells per platform; 16 wells per platform/per year | | 5.4 Wells Per Production Platform; 4.0 Wells Per Producing Platform (USGS)<br>Potentially as high as 25 | | Requirements Depend On Amount Of Production | |

Legend: Kash = Energy Under the Oceans, Kash, et al (1973)
Ad Hoc = Effects of Offshore Oil and Natural Gas Development on the Coastal Zone, for the Ad Hoc Committee on Outer Continental Shelf, by Library of Congress Congressional Research Service

Leasing = Leasing and Management of Energy Resources on the Outer Continental Shelf, U.S. Dept. of Interior (1974)
BLM = BLM Leasing Schedule (June, 1975)
Energy = Energy Perspectives, U.S. Dept. of Interior (1975)
USGS = USGS computer printouts for Texas Federal OCS Development (1976)

# APPENDIX E

# THE OCSOG MODEL



## THE OCSOG MODEL

The direct effects of OCS oil and gas development - that is, the direct employment, land, and water requirements - can be calculated on the basis of activities postulated to take place. Those effects, however, present only part of the total impact picture; indirect effects must also be calculated. The determination of these indirect effects (indirect water requirements, employment in subsidiary activities generated by primary OCS activities, and taxes paid by these subsidiary activities are just a few examples) is a more complex problem than calculation of primary effects.

The study methodology (Appendix A) specifies that these indirect and induced effects (referred to throughout this study simply as "indirect" effects) are to be calculated through the use of an input/output model. An input/output analysis (sometimes referred to as an interindustry analysis) is especially suited to the calculation of indirect effects in a research effort such as this one because of these important features of an input/output model:

1. It can be used to systematically describe a regional economy through the use of equations which represent the trading patterns of the area;

2. It is capable of inter-relating economic and natural resource (water use) data; and

3. The model can be used to estimate future economic activity.

Because of the time and money constraints, the use of an input/output model in this study would have undoubtedly been impossible if an I/O Model for the State of Texas did not exist. Such a model has been developed, however, and has been augmented from time to time by several sub-regional (intra-state) models based on the original State model.

The first State model was developed by the Office of the Governor of Texas in 1973 and has since been updated to incorporate 1972 Department of Commerce data. This State model was the starting point from which the Outer Continental Shelf Oil and Gas (OCSOG) Input/Output Model was constructed. The construction of the OCSOG Model, however, entailed two significant modifications of the State model.

1. The State model was modified to facilitate analysis of the substate regions relevant in this study; and

2. The existing model was modified to incorporate those industrial activities which are specifically related to offshore oil and gas development.

This appendix has as its purpose, therefore, an explication of precisely how these modifications were achieved and, thus, how the OCSOG Model was constructed. Included herein is a brief description of I/O analysis generally and the Texas I/O Model specifically, sub-regional modifications of the State model, offshore modifications of the State model, and the internal operating characteristics of the OCSOG model.

## Input/Output Analysis*

In its essence, an I/O Model is an accounting system which traces the flow of goods and services throughout a regional economy. In such a model, each producing entity is treated as both a producer and as a consumer, in that it consumes resources necessary for production. Those entities which consume only, of course, are treated simply as consumers. (A mathematical description of input/output analysis can be found in Attachment E I.)

An input-output model is presented in matrix form and consists of three tables:

1. The transactions table is the basic table of an input-output model. Essentially, it is a description of sales and purchases for all sectors in the regional economy. Figure E1 is a hypothetical example of an input-output transactions table.

The transactions table consists of the processing or endogenous sectors (agriculture, manufacturing, trades, etc.) plus the final demand or exogenous sectors (households, exports, government, capital formation, and final payments sectors), and imports, gross savings, and depreciation. The processing sectors produce goods and services which are used as inputs by other industries and which are also sold to the ultimate consumer in the final demand sector. Row entries represent a sale by any given sector to another sector. Column entries represent a purchase by any goven sector from another sector. The flow of goods and services is continued throughout the model, since the model employs a double entry accounting system whereby a sale by one sector is purchased by another sector. Finally, the sum of all outputs is equal to $710 (in Figure E1) in a balanced model which accounts for all transactions.

Figure E1. Transactions Table

| Sales / Purchases | Sector | Agriculture | Manufacturing | Trades | Final Demand Households | Total Output |
|---|---|---|---|---|---|---|
| | Agriculture | $ 30 | $ 70 | $ 50 | $ 30 | $180 |
| | Manufacturing | 50 | 60 | 50 | 30 | 190 |
| | Trades | 40 | 30 | 60 | 50 | 180 |
| Final Payments | Households | 60 | 30 | 20 | 50 | 160 |
| | Total Inputs | 180 | 190 | 180 | 160 | 710 |

*This section was taken from the report, "Coastal Economy" written by RPC, Inc. under contract to the General Land Office of Texas, 1975.

2. The direct requirements table is a matrix of technical coefficents which show the amount of input needed from each sector to produce a dollar of output for any given sector. Technical coefficients are derived for processing sectors by dividing each column entry by the sum of the column. In Figure E2, the coefficients for agriculture show that in order to produce a dollar of output, the agriculture sector would require 17 cents of inputs from other agriculture businesses, 28 cents from manufacturing, 22 cents from the trade sectors and would pay 33 cents to households for labor. Figure E2 is an example of an input-output direct requirements table.

Figure E2. Direct Requirements Table

| Sector | Agriculture | Manufacturing | Trades | Households |
|---|---|---|---|---|
| Agriculture | .1667 | .3684 | .2778 | .1875 |
| Manufacturing | .2778 | .3158 | .2778 | .1875 |
| Trades | .2222 | .1579 | .3333 | .3125 |
| Households | .3333 | .1579 | .1111 | .3125 |
| Total Inputs | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

3. Interdependence coefficients from the direct and indirect requirements table show the interrelations of the input of a sector to the outputs of all other sectors both directly and indirectly. These coefficients are important because they show not only the direct effect of a trade between two sectors but also the indirect effect on the economy that is created by the initial transaction. For this reason, the numerical value of these coefficients is larger than the direct requirements coefficients. Figure E3 is a hypothetical example of a direct and indirect requirements table.

Figure E3

Direct and Indirect Requirements Table

| Sector | Agriculture | Manufacturing | Trades |
|---|---|---|---|
| Agriculture | 2.0805 | 1.4607 | 1.4755 |
| Manufacturing | 1.2461 | 2.4919 | 1.5576 |
| Trades | .9885 | 1.0770 | 2.3606 |
| Multiplier | 4.3151 | 5.0296 | 5.3927 |

The direct and indirect requirements table presents a more detailed explanation of the interrelations among all sectors in the model to any given sector than does the transactions table or the direct requirements table. The interdependence matrix can also be extended to include the households row and column in the calculations; the same procedure is used, but the induced effects of households spending are included in the interdependence matrix. This table also includes "multipliers" that can be used in predicting the total economic impact in an area based on a known change in the economy. The summation of each column is a multiplier that can be used as an integral part of impact analysis. By incorporating employment and natural resource data into the model, multipliers can be calculated that show not only the income effect but the socio-economic impact on a regional economy.

## Sub-Regional Modifications of the State Model

The OCSOG Model, as was noted earlier, was based on the Texas State Input/Output Model. The OCSOG Model is made up of seven sub-regional models. In the first phase of its OCS study, RPC divided the Texas Coastal Area into seven different regions; a sub-regional model was constructed for each. The Regions are:

1. Region I - Orange and Jefferson Counties;
2. Region II - Harris, Galveston, and Chambers Counties;
3. Region III - Brazoria County;
4. Region IV - Matagorda, Jackson, Calhoun, and Victoria Counties;
5. Region V - Aransas and Refugio Counties;
6. Region VI - San Patricio and Nueces Counties; and
7. Region VII - Cameron, Hidalgo, and Willacy Counties.

The initial step in developing the regional models was to estimate the total value of output (control totals) for each sector in the model for the region in question. This information at the county level is available from a variety of sources, including the United States Department of Commerce. When the value of output was not available or when it was available only at the State level, Texas Employment Commission data were used to estimate the regional totals. For example, total value of output for the construction industry is available only at the State level from the 1972 Census of Construction. In order to estimate the regional totals, a ratio of construction employment in each region to construction employment in the State was derived and applied to the State total value of output.

Let: $\text{Rshare} = \frac{\text{RempCn}}{\text{SempCn}} \times \text{T.V.O. State}$

Where: Rshare = regional share of total value of output in construction
RempCn = employment in construction in region
SempCn = employment in construction in State
T.V.O. State = total value of output in construction State of Texas

The following list shows the data sources that were used in estimating the control totals for the OCS regional model.

| | |
|---|---|
| Agriculture | Publications from Texas Department of Agriculture and the USDA; Texas Crop and Livestock Reporting Services. |
| Mining | Published and unpublished data from Texas Railroad Commission and Texas Employment Commission; Mineral Yearbook; 1972 Census of Mineral Industries. |
| Construction | Texas Employment Commission, unpublished data; 1972 Census of Construction. |
| Manufacturing | 1972 Census of Manufacturing. |
| Transportation | Texas Employment Commission, unpublished data. |
| Communications | Texas Employment Commission, unpublished data. |
| Utilities | Electric utilities from Texas Employment Commission, unpublished data; Water utilities from 1972 Census of Governments; Gas utilities from Texas Railroad Commission. |
| Wholesale Trade | 1972 Census of Wholesale Trade. |
| Retail Trade | 1972 Census of Retail Trade. |
| Finance, Insurance, Real Estate | Texas Employment Commission, unpublished data. |
| Services | 1972 Census of Selected Services; Texas Employment Commission unpublished data; Texas Education Agency. |

| | |
|---|---|
| Households | 1972 Department of Commerce, Survey of Current Business, 1972 and 1973. |
| Federal Government | 1972 and 1973 Federal Outlays in Texas. |
| State Government | Published data from the Governor's Office of Budget and Planning. |
| Local Government | 1972 Census of Governments. |

Control total data for each regional sector were run in computer program LOQUOT to construct the regional input-output models. Program LOQUOT provides a new input-output model for a sub-region based on a comparison with an existing model for a larger region. The State model was used as the base model in developing each of the regional models.

## Offshore Modifications of the State Model

The data sources used in developing the OCS regional input-output models were generally available for county-level information. However, in all but one case, the data sources did not provide information necessary to identify the offshore oil and gas related services that are a part of OCS activity. For example, the 1972 Census of Mineral Industries provides data for oil and gas field services, such as cementing and well logging services and mud suppliers. However, the data are aggregated into a total county figure and do not specifically identify these industries. Furthermore, the industries are not categorized as to whether they are onshore or offshore related services. In order to identify offshore oil and gas services, it was necessary to conduct personal interviews with appropriate industry officials. The data were obtained by using the questionnaire in Attachment EII and are based on a commonly used survey technique for developing input-output models. The following descriptions denote data sources and estimating procedures relative to each sector.

1. Offshore Drilling Contractors - The data for total value of output and employment were listed in the 1972 Census of Mineral Industries Industry Series MIC 72(1)-13C-5, Table 2A - General Statistics by Geographic Area. The data were listed for the State of Texas and were not reported at the county level. In order to assign the data to various geographic areas along the coast, personal interviews were conducted with offshore drilling contractors in Texas. Also, unpublished data from the Texas Employment Commission were used to substantiate the information from these interviews.

2. Offshore Cementing Services - The Census of Mineral Industries

provides data for onshore oil and gas field services other than drilling contractors. Information from staff at the Bureau of Census confirmed that this data was mainly related to mud, cementing and well logging services. A ratio was derived of total revenue for onshore drilling contractors to that of total revenue for all other oil and gas field services. This ratio was also assumed to be reliable for estimating offshore services. This ratio was applied to the data from the Census of Mineral Industries for offshore drilling contractors to estimate a control total for offshore services. The total was disaggregated into the separate components for mud services, cementing services, and well logging services based on information from offshore drilling contractors. They estimated that if total payments to these sectors for a typical offshore drilling operation were equal to 100%, mud service cost would be 47%, cementing costs would be 25%, and well logging cost would be 28%. The technical coefficients for cementing services were derived from interviews with representatives of cementing services companies.

3. Offshore Well Logging Services - The estimates of total revenue and employment were derived as described in the previous section. The information necessary to allocate the data to specific study sites and to derive the input-output coefficients were obtained from interviews with well logging service company officials.

4. Offshore Mud Suppliers - The estimates of total revenue and employment were derived in the manner described previously. Data for the coefficients and for allocating revenue and employment to various geographic locations were obtained through interviews with mud supply company officials.

5. Marine Pipeline Construction - This sector was restricted to those major pipeline contractors which would take part in any new pipeline construction brought about by increased offshore development. Estimates of total revenue, employment, and data relative to the technical coefficients were obtained through interviews with major pipeline contractors in Texas and in Louisiana.

6. Supply and Service Boats - Information for this sector came from interviews with company officials in Texas and Louisiana. The data were restricted to those companies whose business depends entirely on servicing offshore petroleum activity.

7. Offshore Helicopter Service - Data for helicopter services were provided by company representatives in Louisiana. These companies have Texas-based operations and also have knowledge of other helicopter service operations that are Texas-based. Therefore, they were able to provide the necessary estimates of revenues, employment, and site-specific location of this activity.

8. Offshore Oil Well Supply - Data for this sector were reported in the 1972 Census of Wholesale Trade. The data were aggregated along with other types of machinery and equipment dealers. Therefore, it was necessary to estimate which part of this data was related to oilfield supply business. Information from an interview with staff of the Bureau of Census indicated that at the national level approximately 11% of the total could be attributed to the oilwell supply sector. Their data also indicated that Texas has approximately three times as many oil well supply firms on a relative scale as does the national average. Therefore, 33% of the total revenue data for this sector in Texas was assigned to the oil well supply. The same technique was applied to data for the coastal counties. It was also necessary to estimate what percentage of the oil well supply business in the coastal area was attributed to offshore activity. This data and information regarding employment, technical coefficients, and site specific location of this activity were obtained through interviews with three major oil well supply companies.

9. Offshore Diving Service - Estimates of total revenue, employment, and site-specific location and data for input-output coefficients were obtained from an interview with officials of a major diving company. The data for this sector does not reflect activities of those marine pipeline construction companies which employ their own diving teams.

## Internal Operating Characteristics of the OCSOG Model

Some of the most valuable "tools" developed in an input-output model are the various multipliers that can be used in regional impact analysis. These multipliers are used to estimate changes in the level of income, employment, tax or natural resources based on a changing economy. Multipliers of this type were developed in each of the regional OCS input-output models. One of the most useful of these is the tax multiplier. Tax multipliers were calculated in the model to determine the relationship between federal, state, and local government revenues and the production levels of each industry. Specifically, tax multipliers measure the direct, indirect, and induced effects on federal, state, and local tax revenue resulting from a change in a given industry's sales of goods and services to final users.* They are used to measure the total tax effect as a result of an industry's sales to a final user.

In general, tax multipliers can be of assistance to public and private officials in measuring the impact on public services as a result of a change in the economy. For example, assume that a new manufacturing plant is to be built in a community and the company estimates that total sales of the first year are expected to be x million dollars. By using the tax

*Perrin, John S. "Output Multipliers in Input-Output Analysis," Office of the Governor, Austin, Texas, August, 1972.

multipliers in the OCS input-output model for this manufacturing sector, the potential increase in federal, state, and local taxes can be estimated. This information can be weighed against the public cost of locating the new plant, such as installing new public utility lines or increased demands on government services to estimate the first year's benefits (or cost) to the local government. Also, new state and federal tax revenues can be estimated to determine the increase in total exogenous taxes paid by the local area. This information can be very useful to public and private planners in providing for the orderly management of a local, state, or federal government.

The tax effects relevant to a discussion of the OCSOG Model are of two types. The first type is the final demand-driven tax effect. This type of tax effect quantifies the amount of additional taxes which will be paid to any given tax sector resulting from an increase in sales to final demand by a sector of the economy. The second type of tax effect is the output-driven tax effect resulting from an increase in production by a sector. The type of effect which is applicable in any given situation is dependent upon that situation. For example, if planners are considering steps to take to increase the export of a commodity, the tax effect which would be realized is the final demand type. However, if a new factory were to establish itself in a region, the tax effect of that factory would be the output-driven type.

Tax effects are computed using a direct requirements table and interdependence coefficients table of a regional input-output model. This procedure outlines those direct, indirect, and induced effects on payments to taxes resulting from changes in either production or final demand. For purposes here, it is assumed that final demand has changed. While the computation is the same for both types, to compute the output-driven effects, each columnar element of the interdependence table must first be divided by the diagonal element in that column.

Basically, the total tax effect is composed of the direct effect (that payment to the tax sector directly by the sector whose final demand has changed), the indirect effect (that payment to the tax sector by all the other sectors of the economy whose output supports the output of the original sector), and the induced effect (that payment to the tax sector by all the sectors of the economy resulting from increased purchases by households).

Mathematically, the tax effect resulting when the final demand for gasoline, for example, increases by $1.00 consists of multiplying each value in the gas service stations column of the interdependence matrix by direct requirement of that value's row sector upon the tax sector, and then summing the products.

Let A = matrix of interdependence coefficients,

$A_{i,j}$ = interdependence coefficient in the i-th row and j-th column of the matrix A,

$x_{t,i}$ = direct requirement of the i-th sector upon the tax sector 't', and

m = number of processing sectors in the regional model.

Then the total tax effect is:

$$TE_j = \sum_{i=1}^{n} (A_{i,j} \cdot x_{t,i}) \quad .$$

Briefly, $A_{i,j}$ is the increase in production by sector i required to support a \$1.00 increase in sales to final demand by sector j. Of that amount, sector i must pay to tax sector t an $x_{t,i}$ share. Therefore, sector i pays to tax sector t an amount equal to $(A_{i,j} \cdot x_{t,i})$. Summing the tax effect across all sectors which must increase their production yields the total tax effect.

If the interdependence table used in the above computation excludes households (open model), then the total tax effect consists of only the direct and indirect effects. The indirect portion can be found as follows:

$$Indirect_j = TE_j - x_{t,j}$$

If the interdependence tabel used includes households (closed model), then the total tax effect includes the induced effect which is computed as follows:

$$Induced_j = TE_j - Indirect_j - x_{t,j}$$

Figures E4 through E10 (for Regions I through VII, respectively) present both final demand and output multipliers for those OCS-related industries identified in the input-output model. Both Type I (open model) and Type II (closed model, including households) are presented.

Besides tax multipliers, several other types of multipliers are employed in the OCSOG Model; they are briefly described below.

1. Employment multipliers measure the total increase or decrease in employment based on a change in employment for any given sector. For example, assume that the employment multiplier for an industry is equal to 1.75. Also, assume that employment in this industry increases by 100

Figure E4

Tax Multipliers - Region I (Orange/Jefferson)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .078 | .078 | .002 | .002 | .003 | .003 |
| Cementing Services | .055 | .055 | .011 | .011 | .006 | .006 |
| Well Logging Services | .045 | .045 | .012 | .012 | .007 | .007 |
| Mud Services | .049 | .049 | .012 | .012 | .006 | .006 |
| Marine Pipeline | .039 | .039 | .028 | .028 | .008 | .008 |
| Boat Services | .052 | .052 | .011 | .011 | .011 | .011 |
| Helicopter Service | .082 | .082 | .009 | .009 | .061 | .061 |
| Oilwell Supply | .054 | .054 | .011 | .011 | .008 | .008 |
| Diving Services | .047 | .047 | .004 | .004 | .003 | .003 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .084 | .084 | .003 | .003 | .003 | .003 |
| Cementing Services | .063 | .063 | .012 | .012 | .007 | .007 |
| Well Logging Services | .049 | .049 | .012 | .012 | .008 | .008 |
| Mud Services | .057 | .057 | .013 | .013 | .007 | .007 |
| Marine Piepline | .043 | .043 | .029 | .029 | .009 | .009 |
| Boat Services | .058 | .058 | .012 | .012 | .012 | .012 |
| Helicopter Services | .088 | .088 | .010 | .010 | .062 | .062 |
| Oilwell Supply | .061 | .061 | .012 | .012 | .009 | .009 |
| Diving Services | .054 | .054 | .005 | .005 | .004 | .004 |

Figure E5

Tax Multipliers - Region II (Harris/Galveston/Chambers)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .094 | .094 | .004 | .004 | .005 | .005 |
| Cementing Services | .066 | .066 | .013 | .013 | .007 | .007 |
| Well Logging Services | .063 | .963 | .014 | .014 | .009 | .009 |
| Mud Services | .058 | .058 | .013 | .013 | .007 | .007 |
| Marine Pipeline | .057 | .057 | .033 | .033 | .011 | .011 |
| Boat Services | .053 | .053 | .012 | .012 | .012 | .012 |
| Helicopter Service | .084 | .084 | .010 | .010 | .062 | .062 |
| Oilwell Supply | .067 | .067 | .014 | .014 | .010 | .010 |
| Diving Services | .054 | .054 | .005 | .005 | .004 | .004 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .115 | .115 | .008 | .008 | .007 | .007 |
| Cementing Services | .092 | .092 | .017 | .017 | .010 | .010 |
| Well Logging Services | .080 | .080 | .017 | .017 | .011 | .011 |
| Mud Services | .086 | .086 | .018 | .018 | .010 | .010 |
| Marine Piepline | .073 | .073 | .036 | .036 | .012 | .012 |
| Boat Services | .072 | .072 | .015 | .015 | .014 | .014 |
| Helicopter Services | .104 | .104 | .013 | .013 | .064 | .064 |
| Oilwell Supply | .092 | .092 | .017 | .017 | .012 | .012 |
| Diving Services | .077 | .077 | .009 | .009 | .007 | .007 |

Figure E6

Tax Multipliers - Region III (Brazoria)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .079 | .079 | .002 | .002 | .003 | .003 |
| Cementing Services | .053 | .053 | .011 | .011 | .006 | .006 |
| Well Logging Services | .045 | .045 | .012 | .012 | .007 | .007 |
| Mud Services | .047 | .047 | .011 | .011 | .006 | .006 |
| Marine Pipeline | .017 | .017 | .001 | .001 | .002 | .002 |
| Boat Services | .098 | .096 | .005 | .005 | .009 | .009 |
| Helicopter Service | .179 | .179 | .008 | .008 | .021 | .021 |
| Oilwell Supply | .112 | .112 | .021 | .021 | .010 | .010 |
| Diving Services | .064 | .064 | .005 | .005 | .004 | .004 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .082 | .082 | .003 | .003 | .003 | .003 |
| Cementing Services | .057 | .057 | .012 | .012 | .006 | .006 |
| Well Logging Services | .048 | .048 | .012 | .012 | .008 | .008 |
| Mud Services | .052 | .052 | .012 | .012 | .006 | .006 |
| Marine Piepline | .018 | .018 | .001 | .001 | .002 | .002 |
| Boat Services | .101 | .099 | .006 | .006 | .009 | .009 |
| Helicopter Services | .183 | .182 | .009 | .009 | .022 | .022 |
| Oilwell Supply | .116 | .116 | .021 | .021 | .010 | .010 |
| Diving Services | .068 | .068 | .006 | .006 | .004 | .004 |

Figure E7

Tax Multipliers - Region IV (Matagorda/Calhoun/Jackson/Victoria)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .086 | .086 | .003 | .003 | .003 | .003 |
| Cementing Services | .061 | .061 | .012 | .012 | .006 | .006 |
| Well Logging Services | .057 | .057 | .013 | .013 | .008 | .008 |
| Mud Services | .053 | .053 | .012 | .012 | .006 | .006 |
| Marine Pipeline | .059 | .059 | .036 | .036 | .009 | .009 |
| Boat Services | .054 | .054 | .011 | .011 | .011 | .011 |
| Helicopter Service | .085 | .085 | .009 | .009 | .062 | .062 |
| Oilwell Supply | .057 | .057 | .012 | .012 | .009 | .009 |
| Diving Services | .048 | .048 | .005 | .005 | .004 | .004 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .094 | .094 | .004 | .004 | .004 | .004 |
| Cementing Services | .071 | .071 | .013 | .013 | .007 | .007 |
| Well Logging Services | .065 | .065 | .014 | .014 | .009 | .009 |
| Mud Services | .065 | .065 | .014 | .014 | .007 | .007 |
| Marine Piepline | .065 | .065 | .037 | .037 | .010 | .010 |
| Boat Services | .063 | .063 | .012 | .012 | .012 | .012 |
| Helicopter Services | .095 | .095 | .011 | .011 | .063 | .063 |
| Oilwell Supply | .067 | .067 | .013 | .013 | .009 | .009 |
| Diving Services | .057 | .057 | .006 | .006 | .005 | .005 |

Figure E8

Tax Multipliers - Region V (Aransas/Refugio)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .081 | .081 | .003 | .003 | .003 | .003 |
| Cementing Services | .058 | .058 | .011 | .011 | .006 | .006 |
| Well Logging Services | .050 | .050 | .012 | .012 | .008 | .008 |
| Mud Services | .051 | .051 | .012 | .012 | .006 | .006 |
| Marine Pipeline | .056 | .056 | .036 | .036 | .009 | .009 |
| Boat Services | .050 | .050 | .011 | .011 | .011 | .011 |
| Helicopter Service | .080 | .080 | .009 | .009 | .061 | .061 |
| Oilwell Supply | .056 | .056 | .012 | .012 | .009 | .009 |
| Diving Services | .046 | .046 | .004 | .004 | .003 | .003 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .085 | .085 | .003 | .003 | .003 | .003 |
| Cementing Services | .062 | .062 | .012 | .012 | .007 | .007 |
| Well Logging Services | .053 | .053 | .013 | .013 | .008 | .008 |
| Mud Services | .055 | .055 | .012 | .012 | .007 | .007 |
| Marine Piepline | .059 | .059 | .036 | .036 | .009 | .009 |
| Boat Services | .053 | .053 | .011 | .011 | .011 | .011 |
| Helicopter Services | .084 | .084 | .009 | .009 | .062 | .062 |
| Oilwell Supply | .060 | .060 | .012 | .012 | .009 | .009 |
| Diving Services | .050 | .050 | .005 | .005 | .004 | .004 |

Figure E9

Tax Multipliers - Region VI (San Patricio/Nueces)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .087 | .087 | .004 | .004 | .004 | .004 |
| Cementing Services | .063 | .063 | .012 | .012 | .007 | .007 |
| Well Logging Services | .059 | .059 | .013 | .013 | .009 | .009 |
| Mud Services | .055 | .055 | .013 | .013 | .007 | .007 |
| Marine Pipeline | .032 | .032 | .028 | .028 | .005 | .005 |
| Boat Services | .048 | .048 | .011 | .011 | .011 | .011 |
| Helicopter Service | .081 | .081 | .010 | .010 | .062 | .062 |
| Oilwell Supply | .060 | .060 | .012 | .012 | .009 | .009 |
| Diving Services | .050 | .050 | .005 | .005 | .004 | .004 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .105 | .105 | .006 | .006 | .006 | .006 |
| Cementing Services | .086 | .086 | .016 | .016 | .009 | .009 |
| Well Logging Services | .075 | .075 | .016 | .016 | .010 | .010 |
| Mud Services | .080 | .080 | .017 | .017 | .009 | .009 |
| Marine Piepline | .038 | .038 | .029 | .029 | .005 | .005 |
| Boat Services | .065 | .065 | .014 | .014 | .013 | .013 |
| Helicopter Services | .099 | .099 | .012 | .012 | .064 | .064 |
| Oilwell Supply | .081 | .081 | .016 | .016 | .011 | .011 |
| Diving Services | .071 | .071 | .008 | .008 | .006 | .006 |

Figure E10

Tax Multipliers - Region VII (Cameron Hidalgo/Wallacy)

Type I

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .088 | .088 | .003 | .003 | .004 | .004 |
| Cementing Services | .061 | .061 | .012 | .012 | .007 | .007 |
| Well Logging Services | .057 | .057 | .013 | .013 | .008 | .008 |
| Mud Services | .057 | .057 | .013 | .013 | .007 | .007 |
| Marine Pipeline | .047 | .047 | .032 | .032 | .008 | .008 |
| Boat Services | .050 | .050 | .011 | .011 | .011 | .011 |
| Helicopter Service | .080 | .080 | .009 | .009 | .062 | .062 |
| Oilwell Supply | .059 | .059 | .012 | .012 | .009 | .009 |
| Diving Services | .050 | .050 | .005 | .005 | .004 | .004 |

Type II

| | Federal | | State | | Local | |
|---|---|---|---|---|---|---|
| | Final Demand | Output | Final Demand | Output | Final Demand | Output |
| Offshore Drilling | .107 | .107 | .006 | .006 | .005 | .005 |
| Cementing Services | .085 | .085 | .016 | .016 | .009 | .009 |
| Well Logging Services | .073 | .073 | .016 | .006 | .010 | .010 |
| Mud Services | .082 | .082 | .017 | .017 | .009 | .009 |
| Marine Piepline | .058 | .058 | .033 | .033 | .009 | .009 |
| Boat Services | .067 | .067 | .014 | .014 | .013 | .013 |
| Helicopter Services | .099 | .099 | .012 | .012 | .063 | .063 |
| Oilwell Supply | .079 | .079 | .015 | .015 | .011 | .011 |
| Diving Services | .071 | .071 | .008 | .008 | .006 | .006 |

# ATTACHMENT EI

## Mathematical Explanation of an Input-Output Model

## Attachment EI

### Mathematical Explanation of an Input-Output Model

The derivation of the static, open input-output model consists of four basic components. These components include a transactions table; a direct requirements table; a direct and indirect requirements table; and a direct, indirect, and induced requirements table. All of these components have been covered in the text of this appendix. However, the following symbolic presentation is a more technical explanation of the four input-output tables.

The static, open model is based on three fundamental assumption:*

1. Each group of commodities is supplied by a single production sector.

2. The inputs to each sector are a unified function of the level of output of that sector.

3. There are no external economies or diseconomies. The model also assumes that demand and supply are equated through a horizontal shift in the demand function for each sector as a result of changes in the level of production in other sectors. That is, a change in the demand function for a given industry is a result of a change(s) in the production levels of other industries. This means the factors of production for any given sector are stable over time, i.e., the direct requirement coefficients and technology utilized in production are constant. An assumption of this type is reasonable in the short-run, but is questionable in the long-run especially when there are significant changes in the level of production caused by technological advances.

The transactions table is a production matrix of the economy, i.e., each column in the matrix for any given sector comprises the production schedule for that sector in the static, short-run model. For example, the cells in each column represent the inputs necessary for the total production of that sector. The economy of the study area is composed of n + 1 sectors. All of the sectors except one, final demand, are endogenous. The final demand component is an exogenous sector, that is, it is outside of the processing sectors of the model and is automous. The endogenous sectors are non-autonomous and interdependence coefficients can be developed for these sectors.

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*The information in this section was basically constructed from William H. Miernyk, The Elements of Input-Output Analysis (New York: Random House, 1969), pp. 147-151.

workers. The total employment impact this change has on the area can be estimated by multiplying the direct change of 100 employees x 1.75. The total impact is estimated to be 175 employees including the 100 initially employed.

Employment data for each sector in the OCSOG Model were obtained in most cases from the Texas Employment Commission. The data came from unpublished sources and includes employment for all sectors exclusive of the offshore oil and gas related businesses and agriculture entities. Agriculture employment was estimated from unpublished sources at the Texas Water Development Board and was based on labor input coefficients for each sector. A labor input coefficient (L.I.C.) shows the amount of labor required to produce a given level of output:

$$\text{L.I.C.} = \frac{\text{Total employment in sector x}}{\text{Total value of output in sector x}}$$

Employment totals for offshore oil and gas related sectors were estimated in the manner previously described.

2. Type I Household Income Multipliers measure the direct and indirect change in household income per dollar change in direct payments to households for any given sector. Type II Household Income Multipliers measure the direct, indirect and induced change in household income per dollar change in direct payment to households for any given sector. For example, assume that total wage in a sector increased by $10,000 per year and the Type II income multiplier was 1.65. The total income effect this change would have on household income in the area would amount to $16,500.

3. Final Demand Multipliers measure the total income impact new sales to a final consumer have on the regional economy. They are calculated for each producing sector in the model. If, for example, sales in a given sector increase by $10 million and the final demand multiplier for that sector is 2.50, the total effect on trading patterns in the area can be estimated to be $25 million.

4. Water Resource Multipliers measure the total increase in water consumption in an area or a result of a change in water consumption by a particular industry. Assume that a manufacturing industry's water consumption increases by 100,000 acre feet annually and its water resource multiplier is equal to 4.00. The estimated total demand placed on the regional water supply would be 400,000 acre feet annually including the 100,000 acre feet of water required by that industry.

Water use data came from a number of sources including data that had to be adjusted and data as reported in government publications. The following is a description of the methodology and sources used in obtaining the water use data for the OCSOG Model.

| Sector | Methodology/Source |
| --- | --- |
| A. Irrigated Crops | Inventories of Irrigation in Texas, 1958, 1964, 1969, and 1974, Texas Water Development Board, Report 196; October 1975, Austin, Texas. |
| B. Livestock | Water use on a per day basis times (x) number of animals; data calculated on a county basis and converted to acre feet/year in each region.<br>Cattle - 15 gallons per day<br>Hogs - 4 gallons per day<br>Dairy Cows - 35 gallons per day<br>Sheep/Goats - 2.5 gallons per day<br>Poultry - 11 birds per gallons per day<br>Water use factors supplied by Texas Water Development Board, Agriculture Branch; Austin, Texas. |

Total production for any given sector is represented by the symbol $X_i$. Both endogenous (non-autonomous) and exogenous (autonomous) sectors consume production from all other sectors. Therefore:

$$(1) \quad X_i = X_{i1} + X_{i2} \quad X_{i3} \ldots X_{in} \; X_f \; (i = 1 \ldots n)$$

where $X_f$ is the autonomous sector and $X_{i1}$, $X_{i2}$, $X_{i3}$, $X_{in}$ are the non-autonomous sectors.

As previously stated, the inputs to each sector are a unique function of the level of output of that sector. More specifically, the inputs purchased by each sector are a function only of the level of output of that sector, i.e., the input function is a linear homogenous function. Let $X_i$ and $X_j$ be non-autonomous sectors in order to illustrate the previous assumption:

$$(2) \quad X_{ij} = a_{ij} X_j$$

which shows that the demand for part of the output of one non-autonomous sector $X_1$ by another non-autonomous sector $X_j$ is a unique function of $X_j$.

By substituting equation (1) in equation (2) a more complete equation can be developed:

$$(3) \quad X_i = a_{i1} \; (X_1) + a_{i2}(X_2) + a_{ia} \; (X_3) + \ldots .$$

$$\ldots . . a_{in} \; (X_n) + X_f \; (i=1 \ldots n)$$

This equation (3) may be reduced to:

$$(4) \quad X_i = \sum_{j=1}^{n} a_{ij} \; (Xj) + X_f \; (i = 1 \ldots n)$$

where $X_j$ is the demand function for production by the jth sector from the ith sector and where $X_f$ is the final demand (autonomous) for the output of the ith sector.

Technical coefficients or direct requirements coefficients are calculated from the transactions table by dividing each entry or cell in every column by the sum of the column. These coefficients show the amount of input needed from all sectors by the ith sector to produce one dollar's worth of output. The coefficients are calculated for the non-autonomous (endogenous) sectors only. Equation (2) may rewritten to show the direct requirements equation:

$$(5) \quad a_{ij} = \frac{X_{ij}}{X_j}$$

In order to calculate these coefficients, the inventory change column of the complete transactions model is subtracted from each sector's total gross output to obtain adjusted gross output. Then, each entry in each column of the processing sectors is divided by the adjusted gross output to obtain the technical coefficients ($a_{ij}$) in equation (5). The following is a matrix of technical coefficents from this equation.

$$(6) \quad A = \begin{matrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{matrix}$$

The next requirement consists of developing and inverting a Leontief matrix in order to compute the table of direct and indirect requirements per dollar of final demand. The Leontief matrix is equal to (I-A) where A is the matrix of direct requirement coefficients and I is the identity matrix. (The identity matrix is a matrix where all elements are zero except the main diagonal elements from the top left to the bottom right corner of the matrix which are equal to one). After (I-A) is completed, the new matrix of coefficients showing direct and indirect effects is transposed to obtain $(I-A)_T^{-1}$. This matrix (K) is as follows:

$$(7) \quad K = \begin{matrix} k_{11} & \cdots & k_{1j} & \cdots & k_{1n} \\ \vdots & & \vdots & & \vdots \\ k_{i1} & \cdots & k_{ij} & \cdots & k_{in} \\ \vdots & & \vdots & & \vdots \\ k_{n1} & \cdots & k_{ni} & \cdots & k_{nn} \end{matrix}$$

A further manipulation of the direct and indirect requirements matrix by including the household sector provides an extended analysis of the model. The same procedure used to construct the (K) matrix is followed but the model is closed with respect to the household sector, i.e., the household sector is included with the processing (endogenous) sectors. After the new matrix is inverted the coefficients show not only the direct and indirect effects by sector but the induced income effects as a result of including the household sector in the model. This analysis further explains the interlinkages of the model and presents a more complete explanation of the total effect on the model as a result of a change in any given sector.

Input-output analysis is concerned with determining the interindustry transactions which are required to sustain a given level of final demand. The folowing equation is used to compute a new transactions table when a new final demand sector is inserted into the model.

$$(8) \quad \sum_{j=1}^{n} X_{fi} \times K_{if} = X_i', \text{ then}$$

$$(9) \quad a_{ij}X_i' = T'$$

where $T'$ is the new transactions table.

The first equation (8) multiplies each column of $(I-A)^{-1}$ by the new final demand of each corresponding row. The columns are summed to get a new total from output ($X_i$). The second equation (9) multiplies the direct requirements table times the new total gross output to obtain the new transactions table $T'$. The new transactions table $T'$ is described in the new balanced equation:

$$(10) \quad X_i' = \sum_{i=1}^{n} a_{ij} (X_j') + X_f', \quad (i = 1 \ldots n)$$

As previously mentioned, this model is a static, short-run model. When changing to a dynamic, long-run model all computational procedures remain unchanged. However, the fixed technical coefficients of the original A matrix (6) are replaced by new coefficients computed for each sector. This could be illustrated in equation (10) by changing the technical coefficient $a_{ij}$ to $a_{1ij}$, indicating that all components of the balanced equation have been changed in the dynamic model.

ATTACHMENT EII

QUESTIONNAIRE USED IN SURVEY
OF OFFSHORE OIL AND
GAS INDUSTRIES

# OCS QUESTIONNAIRE

Date:

Firm SIC:

Interviewer:

A. List in order of importance the major groups of products sold for the year:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

B. Average monthly employment for the year: ______________________________

______________________________

C. Total revenue for the year: ______________________________

______________________________

D. Percent of total revenue derived from offshore activities: __________

______________________________

E. Percent of total sales that would be considered a capital item by the customer:

______________________________

F. Percent of total sales according to location of customer:

1. Within Houston SMSA: ______________________________

2. Outside Houston SMSA but within Texas: ____________________

____________________________________________________________

3. Out of State: ______________________________________________

G. Net inventory change of finished goods, production materials, work goods in progress: $____________________________________

H. Cost of production (assume that total cost equals $1.00; give answers in $.05, $.12, etc.) *Each firm should designate major intermediate cost. Note: All goods and services imported from outside the designated study area should be assigned to #6 - Imports:

| Cost/Payment | Location |
|---|---|
| 1. Wages ____________________ | ____________ |
| 2. Federal taxes ____________________ | ____________ |
| 3. State taxes ____________________ | ____________ |
| 4. Local taxes ____________________ | ____________ |
| 5. Depreciation ____________________ | ____________ |
| 6. Imported Goods (outside Houston SMSA) ____________________ | ____________ |
| 7. Rents ____________________ | ____________ |
| 8. Interest ____________________ | ____________ |
| 9. Profits ____________________ | ____________ |
| 10. Gas utilities ____________________ | ____________ |
| 11. Electric utilities ____________________ | ____________ |
| 12. Water utilities ____________________ | ____________ |
| 13. Insurance ____________________ | ____________ |
| 14. Radio & TV ____________________ | ____________ |

15. Telephone ______________________ ______________

16. Transportation __________________ ______________

17. Meals __________________________ ______________

18. Lodging ________________________ ______________

19. Banks or S&L ___________________ ______________

20. Professional service ____________ ______________

21. Medical ________________________ ______________

22. Retail(specify) _________________ ______________

H. Cost/Payment — Location

23. Wholesale(specify) ______________ ______________

24. Construction ____________________ ______________

*25. ______________________________ ______________

26. Imports ________________________ ______________

I. Sources of Revenue - List your major customers by type, by geographical location and percentage of total sale:

Revenue/Sales — Location

1. Agriculture ______________________ ______________

2. Mining ___________________________ ______________

3. Construction ______________________ ______________

4. Manufacturing _____________________ ______________

5. Transportation ____________________ ______________

6. Communication _____________________ ______________

7. Utilities _________________________ ______________

8. Wholesale Trade ___________________ ______________

9. Retail Trade ______________________ ______________

10. Finance, Insurance, Real Estate

______________________ ______________

11. Services ______________________ ______________

12. Government ______________________ ______________

J. Where do your workers live?

1. ______________________ % In ______________ County

2. ______________________ % Outside ______________ County

3. ______________________ % Outside ______________ State

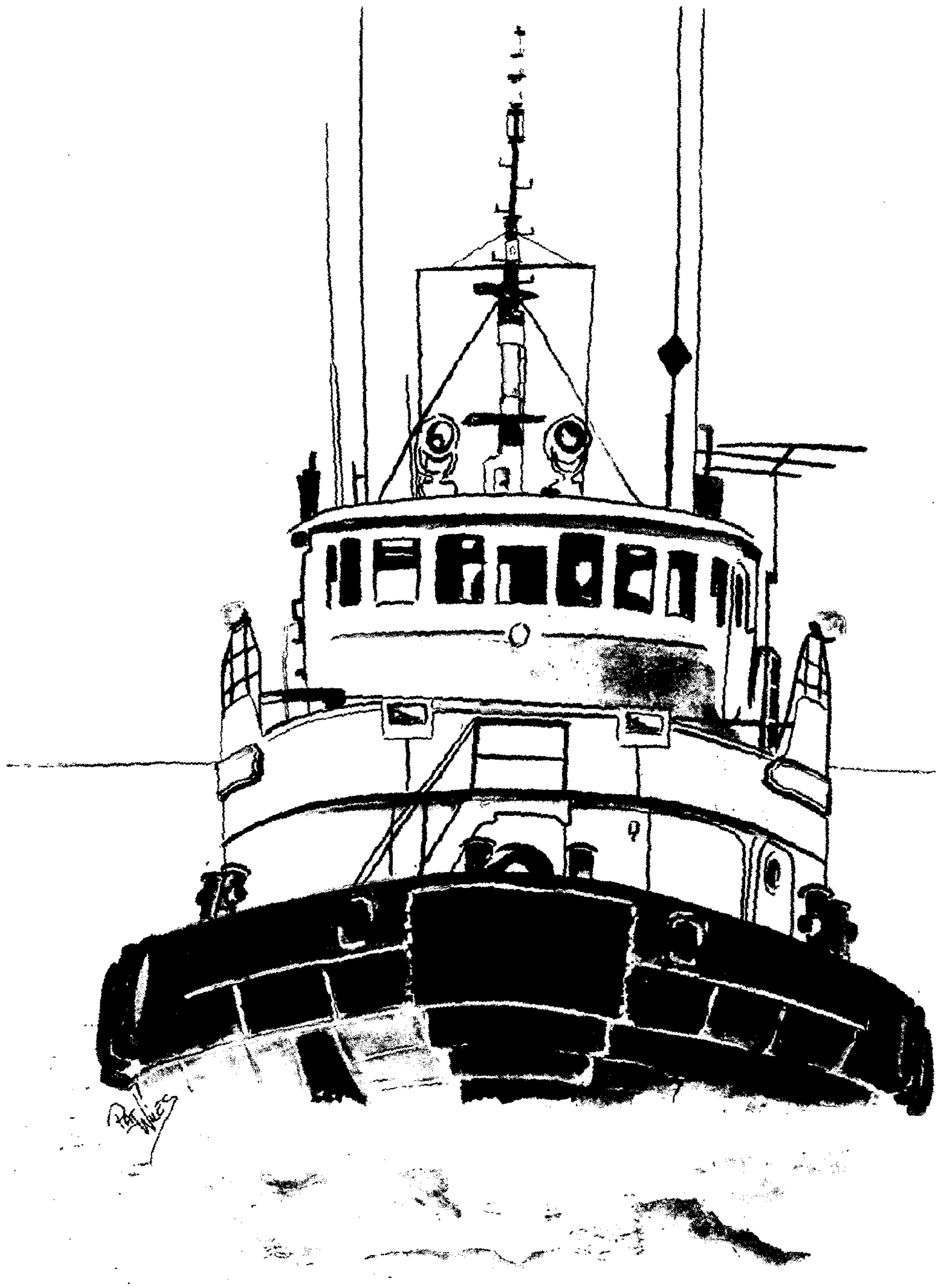
K. For OCS Service and Support firms - list the number of workers your firm would need to provide service to the following rigs:

| | Type of Rig | Workers | Annual Salary |
|---|---|---|---|
| 1. | Jack-up | ______________ | ______________ |
| 2. | Drillship | ______________ | ______________ |
| 3. | Large semi-submersible | ______________ | ______________ |
| 4. | Small semi-submersible | ______________ | ______________ |
| 5. | Fixed Platform | ______________ | ______________ |

K. When applicable, what is your total fresh/saline water use per day: ______________________________________________

# APPENDIX F

# ESTIMATING FISCAL COSTS



## ESTIMATING FISCAL COSTS

Much work has been done concerning methods to forecast state and local government expenditures. The purpose is usually to project total expenditures for specific services over a given time period. While this type of analysis may be extremely helpful to a budget officer, for instance, some form of marginal analysis is preferred when examining the impact of population increases on government expenditures. Methods currently available for examining the latter question are, in order of decreasing sophistication and developmental investment, engineering models, computerized fiscal impact models, simplified infrastructural models, or per capita models.

The first are design tools to be primarily utilized in actually designing expansions of capital facilities to meet growth requirements rather than in assessing aggregate impacts.

The second approach normally incorporates models which, like the engineering models, are very specific to particular communities and require extensive data collection. In addition, costs are disaggregated far more than are the corresponding revenues.

The third type, the simplified infrastructural models, compute the cost of additional service as a function of population, for example, and one or more cost coefficients. Although the services can be estimated by type (sewage, water, etc.), this again presupposes an unwarranted disaggregation of effects. If this approach were employed in this study, total expenditures would be regressed on population; the coefficient would give marginal cost, a constant in linear regression. The regression would be based on historical data, giving marginal cost on the basis of past cost and population data. As a result, an extrapolation of results too far beyond the relevant range (for example, the case of large population influx into a low population area) would be open to question.

The last type, the per capita models, were used in this study; they assume constant marginal costs. More specifically, constant per capita (or average) costs are assumed, implying that marginal costs equal average costs, which are constant. The theoretical validity of the approach then depends on the constant cost assumption.

Studies have been made of the shape of average curves, most testing the hypothesis that economies of scale exist in municipal services. That is, they seek to discover if average costs decrease with increases in population. In one of the more comprehensive analysis, Hirsch (see Figure F1) discusses the shape of average cost curves for three types of city services.

The first, horizontally integrated services, are those whereby a single service is provided by a number of units (public education, police and fire protection, libraries, parks, etc.). They normally account for 80 to 85 percent of all expenditures.

> "... the quasi-longrun cost functions will resemble a U with a flat bottom over a very wide range. Furthermore, since most horizontally integrated services incur relatively little overhead, the short-run and long-run functions tend to approximate one another. They coincide in their flatbottom portion" (Hirsch, 1968, p. 503).

Circularly integrated services (central administration) accounting for three to six percent of expenditures are the second kind of service, and have a U-shaped short-run average unit cost function, with the trough in medium-sized communities. The third type, the vertically-integrated services of water and sewage (eight to ten percent of expenditures) have declining quasi-longrun average unit cost functions until a very large scale is reached.

Empirical studies summarized in Figure F1 confirm these conclusions, as do three studies not included in the figure. Walzer examined economies of scale of municipal police services in Illinois and came to two different conclusions utilizing two approaches. When using a service index in a multiple regression analysis, he concluded that significant economies of scale were found; when using per capita expenditures and population, he discovered that as population increased, expenditures per capita did not vary significantly, other factors considered.

Gabler examined eight states, including Texas, to determine the relationship between population size and varying levels of per capita expenditures on six services. He found no significant statistical relationship for Texas cities between population and per capita expenditures and in general concluded that "...there were relatively few instances of either economies or diseconomies of scale when cities of sizes 25,000 - 250,000 were analyzed...When the very large cities (1960 population of 250,000 or more) are included, the tendency towards diseconomies of scale are more pronounced."

Scott and Feder discovered in their study of 196 California cities with a population greater than 25,000 that per capita expenditures for all local government services taken together were not significantly affected by population size.

In short, from the sources cited, it can be seen that the average cost curve for all services seems to be decreasing or horizontal over a wide range. Within this range the assumption of constant per capita and

Figure F1

COST CURVE STUDIES OF SCALE ECONOMIES

| Name and Year | Service | Type | Result |
|---|---|---|---|
| | *Horizontally integrated services* | | |
| Riew (1966) | Secondary education | S | AUC is U-shaped with trough at about 1,700 pupils |
| Kiesling (1966) | Primary and secondary education | S | AUC is about horizontal |
| Hirsch (1959) | Primary and secondary education | S | AUC is about horizontal |
| Schmandt-Stephens (1960) | Police protection | S & Q | AUC is about horizontal |
| Hirsch (1960) | Police protection | S & Q | AUC is about horizontal |
| Will (1965) | Fire protection | E | AUC is declining with major economies reached at 300,000 population |
| Hirsch (1959) | Fire protection | S | AUC is U-shaped with trough at about 110,000 population |
| Hirsch (1965) | Refuse collection | S | AUC is about horizontal |
| | *Circularly integrated services* | | |
| Hirsch (1959) | School administration | S | AUC is U-shaped with trough at about 44,000 pupils |
| | *Vertically integrated services* | | |
| Nerlove (1961) | Electricity | S | AUC is declining |
| Isard-Coughlin (1957) | Sewage plants | S | AUC is declining |
| Lomax (1951) | Gas | S | AUC is declining |
| Johnston (1960) | Electricity | S | AUC is declining |

*Note:* The following abbreviations are used: S = statistical data; AUC = average unit cost; Q = questionnaire data; E = engineering data.

Source: Werner Z. Hirsch, "The Supply of Urban Public Services", Issues in Urban Economics, Perloff and Wingo, eds. (Baltimore: Johns Hopkins Press, 1968), p. 508.

marginal costs is particularly valid: for the horizontal portion, marginal cost is indeed equal to average cost. For the decreasing portion of the curve, marginal cost is less than average cost, leading to an overstatement of cost (and thus a worst case analysis).

Besides having theoretical justification, the per capita model has the pragmatic advantage of being easy to use. As a result, many impact studies examing the effect of industrial growth upon a locatity utilize per capita expenditures, at least to some degree, in estimating costs. Johnson, when examing an industrial location case in Alabama, estimated costs for significant issues on a marginal basis, while the remaining costs were estimated through the per capita cost method. Shaffer and Tweeten estimated the municipal costs of new residents by multiplying per capita municipal expenditures by number of new residents due to industrial expansion. Hirsch (1964) used per capita operating and capital costs. Finally, Garrison assumed that the cost of new students without reducing the quality of education was equal to the average local revenue per student.

OCS impact studies expecially tend to use per capita models to estimate costs. Examples include those done by Wilcox and Mead (Santa Barbara Channel), Woodward-Clyde Consultants (Mid-Atlantic), and Resource Planning Associates, Inc.

To summarize, per capita models are an accepted method commonly utilized to estimate the cost of government service. The underlying constant cost assumption, while a simplification, does mirror reality fairly well. It is doubtful that the increased accuracy produced by more sophisticated approaches warrants the additional costs which would be incurred.

# APPENDIX G

# SURVEY OF SELECTED MODELING TECHNIQUES

SURVEY OF SELECTED MODELING TECHNIQUES

## Regional Economic Models

Regional models aim at identifying long-range, regional, economic impacts of a given change. Such models include the Harris Model, the MIT Sea Grant Models, input/output models, and the Regional Impact Multiplier System (RIMS).

### I. Harris Model

The Harris model is a multi-regional, multi-industry model. It makes use of input-output relationships to reflect linkages among industries in a region, but it is not an input-output model. Autonomous changes in the components of final demand such as business investment, government expenditues, or production as the result of the location of a new industry in a region affect the output of regional industries based on national inter-industry coefficients. Changes in the demand for the output of regional industries lead to changes in regional payrolls and income and to changes in the demand for retail trade and services. Induced changes in investment are also permitted in the model. For example, it is hypothesized that increases in industry output lead to additional investment in equipment, and increases in area personal income induce new construction for residences and public facilities.

The Harris model can be used to examine the effects of locating one or more new industries in a region. It also attempts to capture the extent to which the growth in one industry may attract new activities or expand the output in existing industries, or the extent to which the location of one or more new activities may lead to a decline in some other activities because of a competition for resources.

The Harris model is considered to provide consistent results in two senses. First, national control totals can be established for employment and other economic variables in total and by industry. The regional model then allocates shares of the national values to geographic areas based on the historic structure of the area economy and estimated economic relationships. This procedure ensures that forecasts for the industries in the area are not independent of expected national and regional trends. Second, the model allows for consistent analysis in that the results of all the impact cases studied reflect the same assumptions regarding the economic behavioral relations in the model. Thus, there is a basis for the systematic comparison in evaluating, for example, the regional economic consequences of petroleum refineries located in two areas because the assumptions and methodology are the same for both cases. This is an advantage when studying alternative development strategies.

## II. MIT Sea Grant Models

A package of four models was developed by MIT to assist in identifying regional economic impacts in the New England area resulting from OCS development of Georges Bank resources. The models simulate the petroleum flows, transport, processing and distribution activities, and the financial flows through time associated with particular hypotheses.

EXCRUDE, the extraregional crude package, estimates the national cost and investor cost of foreign crude landed at a specified refinery considering total amount delivered over time, distance to the source, ship operation and port operation characteristics, payments to the exporting nation, and other factors. To arrive at national and investor costs, EXCRUDE simulates a set of decisions on selecting and chartering the number and size of tankers needed to move crude on the hypothesized schedule between loading and unloading ports. The model enables determination of cost reductions which would result from port modifications increasing draft.

OFFSHOR, the offshore package, determines the national cost, regional payrolls, and investor cost associated with the Georges Bank development.

The model considers the producibility of the formation and possible regulatory constraints and simulates development decisions made by the investor subject to a large set of variables concerning physical, economic and other constraints. OFFSHOR generates oil and gas production over time, shows platform drilling, pipeline and tanker activity over time, identifies private and public revenues, and determines outlays for equipment operation and acquisition. The production schedule used by the model is that which maximizes the after-tax revenues of the investor.

REFINE TWO, the refinery package, develops investor costs for a refinery based on the postulated laboratory analysis of the available crude and the range of products which can be produced from that stock. Both capital and operating costs are developed.

PRODIST, the product's distribution package, simulates the distribution of products from a refinery to each of eight specified New England ports. Both vessel and pipeline systems are considered and selection is based on maximizing investor profit. In addition to selecting the best general system, the model sizes barges or ships under the vessel option and determines diameter and pumping power for pipelines.

## III. Input/Output Models

Use of an input/output model provides a means of approximating the economic activity generated throughout a sectoral range resulting from activity in one or more driving sectors. In the case of OCS development off Texas, activity in the industry sectors directly related to exploration, production, refining and their immediately allied services provides the basis for model operation. (see Appendix E.)

Input/output models typically are keyed to the inter-sectoral relationships prevailing in the area for which they are designed. Their application to other areas requires extensive revision, similar to development of a new model.

The Texas Input/Output Model is a mathematical measurement of market transactions among Texas industries and of the relationship of Texas to out-of-state industries through imports and exports. The empirical estimates of the relationships are based on survey data of Texas industries, census data, and budget data for agricultural industries, updated most recently in 1972.

The model is static-dynamic. That is, iterations of the computation of required sectoral outputs related to activities in which final demand is specified are done on an annual basis, but the program accomodates various time inputs of final demands as well as technical changes, prices, and other factors of the relationship. Construction of the model is such that sectors can be identified at various levels of detail. Original development of the model on a statewide and state-national basis aggregated individually developed sets of intersectoral relationships for nine regions of the state. Capability has been retained to operate the model for selected sub-state areas.

Information resulting from the Texas Input/Output Model includes employment levels; personal income; taxes paid to local, state, and federal governments; water requirements; and other factors. In addition, the Texas Input/Output Model provides a means to identify total employment and those other requirements needed to generate infrastructural requirements.

The Texas Input/Output Model has potential future application in assessment of impacts of OCS development. Particularly, it can be used to help identify the types of structural changes likely to occur in interindustry relationships if substantial quantities of new oil and gas production results from OCS activities which affect petroleum product pricing. In this regard, the model's identification of industries' dependence on various goods and services can be used to consider fuel substitutions and quantities of fuel taken off the market by various sectors at specific prices.

IV. Regional Impact Multiplier System (RIMS)

RIMS is a system through which input-output multipliers can be developed without establishing an entire input-output model. The process incorporates the industrial output multiplier for both the direct and indirect effects of a given industrial sector. Direct effects are obtained from a national regional input-output table and are regionalized through use of location quotients generated with earnings data. The direct effect is then inserted into a predictive equation to obtain indirect effects. The results of the process are total requirements coefficients which can be used to determine the interindustry impacts of a change in the demand for the products of the primary industry.

## Environmental Impact Identification Models

OCS activities can generate a wide range of environmental impacts resulting from the offshore activities, directly related on-shore industrial activities, and satisfaction of the induced requirements of an expanded population and economy. Identification of the types and nature of environmental impacts which will occur from postulated OCS development may be carried out on several levels, depending on the extent to which effects are to be traced and the need for quantification of the impact.

Described below are two modeling procedures which indicate the range of sophistication available in impact identification. Models relating to impact quantification are described in a subsequent section.

I. A Procedure For Evaluating Environmental Impact

This modeling procedure developed by L.B. Leopold, et al, for the U. S. Geological Survey, is typical of several techniques for identification and general evaluation of environmental impacts. A matrix is provided which details 100 actions and 88 environmental characteristics giving the potential for identification of 8,800 possible interactions. The following are representative of the degree of detail in which impacts and actions are included:

| Impacts | Actions |
|---|---|
| water quality | industrial sites and buildings |
| atmospheric quality | highways and bridges |
| deposition/sedimentation | transmission lines |
| aquatic plants | blasting and drilling |
| fish | mineral processing |
| scenic views and vistas | trucking |
| wilderness qualities | emplacement of tailings |
| health and safety | spills and leaks |

While not totally comprehensive in either the types of actions which might be taken or the environmental characteristics which might be noted, it does provide the user a guide for identification of major impacts.

Beyond identification of action-impact relationships, the model provides a system for the analysis and numerical weighting of probable importance and magnitude of each identified relationship. The degree of accuracy obtainable with the procedure depends upon the extent to which factual bases can be established for the appraisal of magnitude and importance. Those relationships which are assigned relatively high values for either magnitude, importance, or both are intended to represent areas requiring detailed consideration.

If desired, the matrix and the associated procedure for its use lend themselves both to refinement by subdivision of the environmental characteristics and actions listed into more basic units, and to extension by the addition of other actions and characteristics. Various authors have identified similar matrices or described the components of matrices, some particularly applicable to the coastal areas of interest. The San Diego planning system, described below, also provides significant input for construction or refinement of an environmental action-effect matrix.

## II. San Diego County Planning System

The San Diego County Planning System is representative of the types of methodologies developed in recent years which use computerized modeling to effect detailed accounting of interactions between development actions, environmental impacts, and site-specific characteristics. The planning system and others like it require very extensive knowledge of the area to be studied, expressed as data on specific "cells", regarding slope, land capability, existing use, geology, vegetation, climate, precipitation, drainage, and other characteristics. As an example of detail, 242 soil types in the San Diego area are considered in the establishment of 12 capability classes according to suitability for mineral extraction, effluent disposal, use for various crops and physical characteristics. Similar levels of detail are used for other site descriptions in each cell. Cell sizes range from 1000 square feet to 111 square feet, resulting in very large amounts of information to be obtained, screened, and coded.

Once the data base is complete, the San Diego Planning system enables:

1. evaluation of the environmental impact from a given development in a specific location;

2. identification of the "best" location for a given development; and/or

3. identification of the allowable extent of development in a specific location for a given environmental impact.

The model also includes considerations for the cost of providing services to various areas according to their location (distance) and of site characteristics in determining the "best" plan.

The San Diego Planning System utilizes an approach to environmental impacts different than the matrix approach described above. For example, whereas the matrix approach identified "highways and bridges" as a developmental action, the San Diego approach identifies components of highways such as cut, fill, compaction, roads, fences, and motor vehicle operation. Extensive charts are provided in the description of the system as examples of the environmental effects of such actions.

It is not always feasible to identify and collect the types of data needed to effectively use an approach such as that represented by the San Diego Planning System. However, specific communities and/or regional planning organizations may have use for such detailed analytical procedures after major OCS developmental decisions are made on a firm basis. In the interim, at least two aspects of the San Diego approach are useful for consideration, including:

1. use of the somewhat unusual approach of considering component actions as a means of supplementing a matrix approach; and

2. use of the charts of component actions versus environmental effects as a basis for preparing qualitative descriptions of environmental impacts.

There are, of course, countless other environmental impact assessment models, methodologies, or routines. The two models described above are intended only to provide an indication of the range of complexity available.

A more detailed listing of environmental impact evaluation models can be found in any of several bibliographies. Among them are:

U.S. Department of Interior. National Park Service. Environmental Impact Assessment Methodologies: An Annotated Bibliography, by Richard C. Viohl, Jr. and Kenneth G.M. Mason. Monticello, Illinois: Council of Planning Librarians, 1974.

and

Warner, Maurice L. and Preston, Edward H. A Review of Environmental Impact Assessment Methodologies. Washington: United States Environmental Protection Agency, 1974.

## Infrastructural Costs Models

Provision of the additional community services required by the OCS activity-induced population and industry growth will require some presently unknown costs. The amount of those costs is expected to be significant, particularly in areas where the present infrastructure is small compared to potential growth, where services now provided are inadequate, and in those cases where considerable lag time exists between the cost of providing community services and tax revenues generated by OCS or OCS-related activities. Various techniques have been used to approximate infrastructure costs resulting from growth.

Four general approaches to determining infrastructure costs are described below; each differ substantially in their sophistication. Generally, the more sophisticated approaches can be expected to produce the most accurate estimates of cost. However, their complexity and costs of use increase dramatically with increasing sophistication, and it is not assured that the improvement of results warrant the additional cost.

### I. Urban Systems Engineering Models

A number of packages of urban systems engineering models have been developed through seven demonstration programs of the U.S. Department of

Housing and Urban Development. The models include those for water supply, sewage, solid waste, stormwater runoff, and other infrastructural systems. Generally, the models enable the planner to rapidly translate assumed development patterns into costs for the modeled services. Some models can assist in optimization of procedures for providing services. Like the San Diego Planning System, these models are complex, expensive to prepare for use, and require extensive amounts of site-specific information.

The Urban Systems Engineering project carried out at Everett, Washington, is a well developed example of such programs. Models developed for use in the project include five basic sets of computer-based planning tools for establishment and use of the solid waste management, sewage planning, water systems planning, and storm drainage planning. Numerous separable programs are included in each set.

The data base program set includes an activity allocation model to allocate employment to subareas, demand forecasting to generate demands, and the necessary programs to screen data for consistency and to store it in easily retrievable form. The data base consists of past and current census data, population and employment forecasts, historical demand parameters, and climatic data. Land use, assessed dwelling units, natural features, and other site-specific information are included in the data base for 40-acre cells.

The solid waste planning program determines the optimal expansion plan for waste processing facilities. The waste shipment problem is solved for each year in the planning horizon to determine the optimal flow of solid waste from source through processing to ultimate disposal. The entire process results in a series of N-best plans ordered according to cost. These plans may be examined in sequence when considering their political and social consequences, which cannot be modeled directly.

The development of sewerage plans utilizing the methodology requires several steps. Forecasts of average and peak sewage flows, population, and infiltration per sewer basin are calculated to provide the primary demand drive for the sewer planning program.

The sewer planning program has the capability to evaluate an existing sewer network and define an expansion network. Treatment plants are planned and/or expanded as required. In designing any element of the system, the program selects the minimum cost element which will handle the required flow without violating constraints. Since the sewer planning program considers a multi-year interval, the final output is a minimum cost-time phased expansion of the input network.

Four computer programs comprise the flood control and storm drainage facilities planning package. These four programs are used to analyze and locate problem areas under assumed or existing land use configurations.

Subsequently, the programs can be used to analyze the consequences of proposed changes on the remainder of the flood control and drainage system.

As with the San Diego Planning System, the complexity and detail of the Urban Studies Engineering System are greater than is required for initial identification of OCS development impacts. In effect, they are design tools and their primary use lies in the future when communities or regions must consider actual design of facility expansions to meet growth requirements. However, the eventual need for such detailed computerized planning tools should be considered in any design of data bases and/or data collection efforts undertaken in the near future.

## II. Fiscal Impact Models

A series of computerized models have been developed as part of Florida's effort to analyze coastal effects of offshore oil development. These models are less detailed than the design models described in the preceeding section. They differ in that their primary purpose is to assess cost, based on an approximate design of facilities, whereas the identification of costs is secondary to system design when using the urban systems engineering models.

The fiscal impact models have been developed to treat a number of community services including drainage, fire, libraries, streets and highways, welfare, health, police, schools, and water. Estimates are prepared either for the service or, where the service is easily divisible, by component. Water service, for example, is subdivided into the components of production and treatment, storage, transmission, and distribution. Costs are determined for requirements due to various residential types and income levels, retail and services categories, industries, and offices.

The fiscal impact models are specific to particular communities. They reflect the type and capability of the existing system described by service demand components, sets of decision rules for service expansion, and unit cost coefficients. Input to the models are the characteristics to be analyzed in terms of location, number of housing units, floor space in manufacturing, and other information. Based on these inputs, the models generate estimates of the additional demand or need for services resulting from the development. Demands are compared with existing system capacities to determine if expansions are required. If so, the decision rules are used to determine the cost of the expansion and to allocate an appropriate share of the expansion cost to the new development. Where existing system capacity is sufficient, costs are allocated to the new development considering current replacement cost deflated to original cost and remaining life.

The allocation of costs is made among municipal, school, and special district units. Revenue, considering various taxes, fees, permit costs, and subventions is allocated among the same units.

Use of the fiscal models requires extensive data collection and calibration efforts to prepare them for use in each community in which they are to be applied.

## III. Simplified Infrastructure Modeling

Costs for the expansion of communities' services can be modeled in simplified forms suitable for manual computation. A simplified modeling approach can vary greatly in the degree of detail with which system requirements are determined and costs are estimated. A wide range of latitude exists in adapting such models for a specific use to reflect more detail in the consideration of those services thought to be particularly sensitive to growth impacts.

In general form, the simplified models compute the cost of additional service as a function of population, number of households, or other appropriate growth measures and one or more cost coeffecients. For example, sewer collector system costs, generally dependent on the number of new households, might be represented as: cost = $T_L CN_H$ where $T_L$ is the local share of cost for construction of collector systems expressed as a percentage, $N_H$ is the number of new households associated with development and C is a coefficient combining demand and cost.

Models of this type are not particularly convenient for use where large numbers of alternatives are to be investigated. Nor do they lend themselves to consideration of the economic implications of using, but not exceeding, available capability. Their principal advantage lies in the rapidity and ease with which they can be prepared and used to approximate costs.

## IV. Per Capita Models

Per capita models provide an extension of present total cost based on expected population growth. (For an extensive discussion of per capita cost models, see Appendix F).

## Estuary Water Quality Models

OCS development-induced population growth and industrial activity is expected to occur primarily adjacent to bays and estuaries. The effect of any increased waste flow into these environmentally sensitive areas may be of particular concern. Modeling offers one means of quantitatively evaluating the impact of this aspect of growth if water quality is identified as a critical issue.

A large variety of mathematical models have been developed for simulating various aspects of water quality in rivers, estuaries and impoundments. The numerous models are of differing degrees of complexity and for various specialized purposes. While most relate the mass loading of one or more constituents to its effect on water quality, some have additional capabilities to cost treatment needs or to evaluate dilution requirements to maintain given water quality levels.

With the exception of sedimentation studies, physical models have only limited use for water quality related purposes. Generally, the complexities of mathematically modeling estuarine-related sedimentation problems is so complex that the cost and time is in the range of constructing a physical model.

The following descriptions identify some of the estuary water quality models which might be considered for use in an assessment methodology in the event water quality becomes a critical concern.

### I. Galveston Bay Models

A number of water quality models have been developed for Galveston Bay and for the Houston Ship Cahnnel which are closely interrelated and intended to be used with a single hydraulic model. The hydraulic model is considered to be the basic Galveston Bay model. It predicts the distribution and quantity of wastes dischared into the system. The several water quality models include those for BOD/DO, Nitrogen, Salinity, and Temperature. In addition, a computerized data base has been developed to assist in storage, retrieval and processing of the vast amounts of data related to this modeling program.

## II. Corpus Christi-Aransas-Copano Bay Models

This model was developed at the University of Texas with support by the Texas Water Development Board and the Office of Water Resources Research, U.S. Department of the Interior. The overall model includes five separate sub-models linked through a common set of input-output requirements. The five component models include: HYTID (tidal hydrodynamics); STERM (short term transport model); LOTRAN (long term transport model); TRANSS (steady-state, convective-dispersion model); and an unnamed dynamic convective-dispersion model. The development was based on the previously described modeling in Galveston Bay.

Thus far these models have had varying application. HYTID, the hydrodynamic model, has been applied to San Antonio and Matagorda Bays and to the combined Corpus Christi-Aransas-Copano Bay system. LOTRAN, limited to the simulation of total dissolved solids, has been used as the quality portion of the model in both applications to date.

## III. Corpus Christi Bay Models

Subsequent to their original use and development, the HYTID and LOTRAN models have been revised as part of a research project entitled "Establishment of Operational Guidelines for Texas Coastal Zone Management." The object of the modeling work was to develop and calibrate transport models which simulate the effect of changing river inflows and wastewater discharges in Corpus Christi Bay. Reducing the operational scope of the original models to suit just Corpus Christi Bay required the development of new boundary conditions at Rockport as the eastern boundary of the new model. The advantage of the reduction in model coverage was the increase in resolution by enabling smaller computational cells.

Information necessary for input to the hydrodynamic model includes Gulf tides, Upper Laguna Madre and Aransas Bay Tides, freshwater inflows, diversions, waste discharges, wind magnitude, wind direction, wind duration, evaporation, and precipitation.

The model has one additional feature of particular interest. It can be used to cost treatment works to maintain particular quality levels under varying policy assumptions. Using this feature, the model can be an aid in testing management schemes for multiple point discharges.

## IV. Other Estuary Models

If water quality proves to be an important consideration in bays and estuaries to which specific models have not already been applied, a more difficult choice exists as to the particular model to be applied. A number of general models and variations thereof are available as illustrated by the following descriptions of the Dynamic Estuary, Tidal Temperature, RECEIV and RIVSCI models.

The Dynamic Estuary Model (DEM) was originally developed by Water Resources Engineers, Inc. for the Public Health Service, Division of Water Supply and Pollution Control, and was then developed further for the Federal Water Pollution Control Administration (FWPCA) and for the State of California. The Federal Water Quality Administration (FWQA), successor to FWPCA, completed its development and refinements for use in studies of the San Francisco Bay-Delta estuary and the San Diego Bay, resulting in the FWQA version of the DEM. Further improvements resulted in the EPA version described here.

DEM is a dynamic equilibrium model. Any non-stratified estuary which does not contain extensive tidal flats may be modeled. DEM consists of two distinct programs. The hydrodynamic program (DYNHYD) computes the dynamic flows, velocities, and water surface elevations in the channels and nodes of the network representing the estuary, and its physiographic characteristics. These outputs from DYNHYD are then used by the quality program (DYNQUA) as the hydrodynamic base for the water quality calculations. DYNQUA computes the time varying concentrations of up to five water quality constitutents throughout the network. These constituents may be a mixture of conservatives and non-conservatives, and any two non-conservatives, such as DO and BOD, may be linked.

The Tidal Temperature Model (TTM), also known as the Columbia River Estuary Model, was developed by the Pacific Northwest Water Laboratory of the FWPCA by incorporating meteorological inputs and dynamic water temperature simulation into a version of the Dynamic Estuary Model. TTM is a dynamic equilibrium model for use in the simulation of water quality conditions including water temperature in estuaries. Any non-stratified estuary which does not contain extensive tidal flats may be modeled. The model is similar to the DEM model but has the added option that one of the constituents modeled may be water temperature.

TTM consists of two distinct programs. The hydrodynamic program, HYDRA, computes the dynamic flows, velocities, and water surface elevations in the channels and nodes of the estuary system as a function of tidal, tributary, and waste inflows to the estuary, and its physiographic characteristics. These outputs from HYDRA are then used by the quality program QUALTEMP as the hydrodynamic base for the water quality and temperature calculations. QUALTEMP computes the time varying concentrations of up to five constituents, including temperature, throughout the network. These constituents may be a mixture of conservatives and non-conservatives, and any two non-conservatives, such as DO and BOD, may be linked.

RECEIV is the receiving water module of the Storm Water Management Model developed by Metcalf and Eddy, Water Resources Engineers, and the University of Florida. RECEIV was developed by incorporating into a previous dynamic equilibrium model the capability to simulate the transient behavior and associated problems caused by dynamic storm water inflows. While RECEIV was derived originally from the Dynamic Estuary Model, it includes a number of modifications which make it significantly different from DEM. Further development of the RECEIV model by Systems Control, Inc., resulted in RIVSCI, a version having extended capabilities.

Any non-stratified stream or estuary system may be modeled with RIVSCI. RIVSCI has the capability to simultaneously model five conservative constituents and eleven non-conservatives. RIVSCI models the dissolved oxygen budget, nutrient cycles, coliform and algal life processes, and benthic demands and releases. The model consists of two distinct modules. The hydrodynamic portion, SWFLOW, computes the dynamic flows, velocities and heads in the channels, and nodes of the system as a function of the inflows and the physiographic characteristics of the system. The output from SWFLOW is used by the quality module, SWQUAL, as the hydrodynamic base for the water quality calculations. SWQUAL computes the dynamic constituent concentrations throughout the network as a function of the concentration of constituents in inflows, advection, dispersion, growth, decay, and settling.

RIVSCI has been tested and verified only for non-estuarine, steady-state cases. Applications using tidal or other time-varying inflows should be approached with caution, although they have been verified with its predecessor, RECEIV.

None of these four models are applicable to a strongly stratified estuary. This should be kept in mind since it is a common occurrence for an estuary to be effectively mixed during the low flow period of the year and stratified into two distinct layers during the high flow period of the year. Each of the estuary models utilize a chosen tidal cycle which repeats itself, resulting in a quantified (hydrodynamic) solution which also repeats itself every tidal period (dynamic equilibrium). The DEM and TTM are truly dynamic equilibrium models, since they accept only steady-state wasteload inputs. However, RECEIV is a dynamic model, and accepts transient inputs, such as non-steady and non-cyclic storm water inflow qualities.

The Texas Water Development Board has also developed tidal hydrodynamic and water quality models for use in shallow, irregular, non-stratified estuaries. The models include HYD-I, the hydrodynamic model and SAL-I, the quality model.

The HYD-I model can take into account submerged reefs, overflow over barrier islands, fresh water inflow, evaporation, tides, winds, and other variables. It computes the temporal and spatial distribution of velocities and water surface elevations throughout the estuary based on full mixing.

SAL-I, the mass transport model, can be used to analyze the distribution of salinity, effect on salinity of increased or decreased withdrawals or inflows, and effect of altered circulation patterns. The model can also be used to simulate the transport of any other conservative quality-constituents. Considerable data is required to calibrate the model.

In addition to the foregoing, several other types of estuary models are available, each with its own characteristics as regards boundary conditions, simulation method, and others. Several good descriptions of estuary modeling techniques and problems are available in such publications as the following:

Pritchard, D.W. "Estuarine Circulation Patterns." Proceedings of the American Society of Civil Engineers 81 (1955): 717.

Idem. Estuarine Hydrology. New York: Academic Press, 1956.

Tracor, Inc. Estuarine Modeling: An Assessment. Washington: Government Printing Office, 1971.

Another separate type of water quality model is represented by the Estuary Ecologic Model (ECOMOD). The Estuary Ecologic Model is a dynamic model for use in the simulation of water temperature and water quality in non-stratified estuaries. ECOMOD has the capability to simultaneously model two conservatives and nineteen non-conservatives. ECOMOD models the dissolved oxygen budget, nutrient cycles, coliform and algal life processes, benthic demands and releases, temperature, the detritus cycle, and zooplankton and fish cycles.

ECOMOD consists of two distinct modules. The hydrodynamic portion, HYDRO, computes the dynamic flows, velocities and heads in the channels, and nodes of the system as a function of the inflows and physiographic characteristics of the system. The output from HYDRO is used by the quality module, ECOSIM, as the hydrodynamic base for the water quality calculations. ECOSIM computes the dynamic constituent concentrations and water temperatures throughout the network as functions of the temperatures and concentrations in the inflows, and of advection, dispersion, growth, decay, settling, and meteorological conditions.

## Outfall Models

Increased population and economic activities will result in the production of greater quantities of waste. Depending on the approach taken to waste treatment and the extent to which environmental impacts are to be evaluated, it may become desirable to evaluate various types of waste outfalls with respect to their site or whether they reach either the surface or bottom of the receiving water body. Waste discharges containing oil also result from the operation of oil/water separators. Because of its chronic occurrence and potentially toxic effect, the fate of the discharge plume and its pattern of dispersion may become of interest in the evaluation of environmental impacts. Several models useful for these types of situations have been developed.

### I. Plume Model

A general model for use in investigating outfalls into water bodies without strong movements was developed in 1971 by the Pacific Northwest Laboratory of the EPA, Region X. The present model, named PLUME, is based on earlier ocean outfall design development work by the FWPCA. It solves for the geometric and dynamic behavior of a buoyant round plume of sewage or industrial waste issuing from a port into stagnant, density-stratified surroundings.

### II. MIT Dispersion Model

Discharges from oil/water separators could contain a high percentage of water soluble aromatics, as separation processes are generally ineffective against that portion of the oil. The aromatics are one of the most toxic fractions and their fate is, therefore, of particular interest. A dispersion model for estimating the hydrocarbon plumes emanating from the oil/water separator was developed as part of the Georges Bank study by MIT.

This model uses two-dimensional dispersion to obtain estimates of the area within which hydrocarbon concentrations exceeding a specified amount will be found.

## Spill Models

The environental aspects of major oil spills are of great concern. Effects of spills appear to be particularly adverse in cases in which oil reaches shore or shallow depths before sufficient weatherings. Offshore spills are moved by a combination of winds, tides and currents.

### I. MIT Spill Trajectory Model

As part of the Georges Bank study by MIT, a computerized model was prepared for analysis of the spread and movement of spills. The program tracks a hypothetical spill from a postulated point of occurence by randomly sampling the wind speed and moving the spill in accord with the wind and user specified currents. Spills are tracked for a fixed period of days of until they are computed to have reached shore.

Repetitive use of the spill trajectory model with winds and currents characteristic of particular seasons and areas enables identification of the likelihood of spills at certain points reaching land and the extent of weathering which can be expected.

## Groundwater Models

Population growth induced by OCS development may have significant impact on groundwater availability both through interference with recharge and increased withdrawals to meet water supply requirements. Quantifying groundwater effects is complex and, if required in any detail, would probably need to be determined through a model.

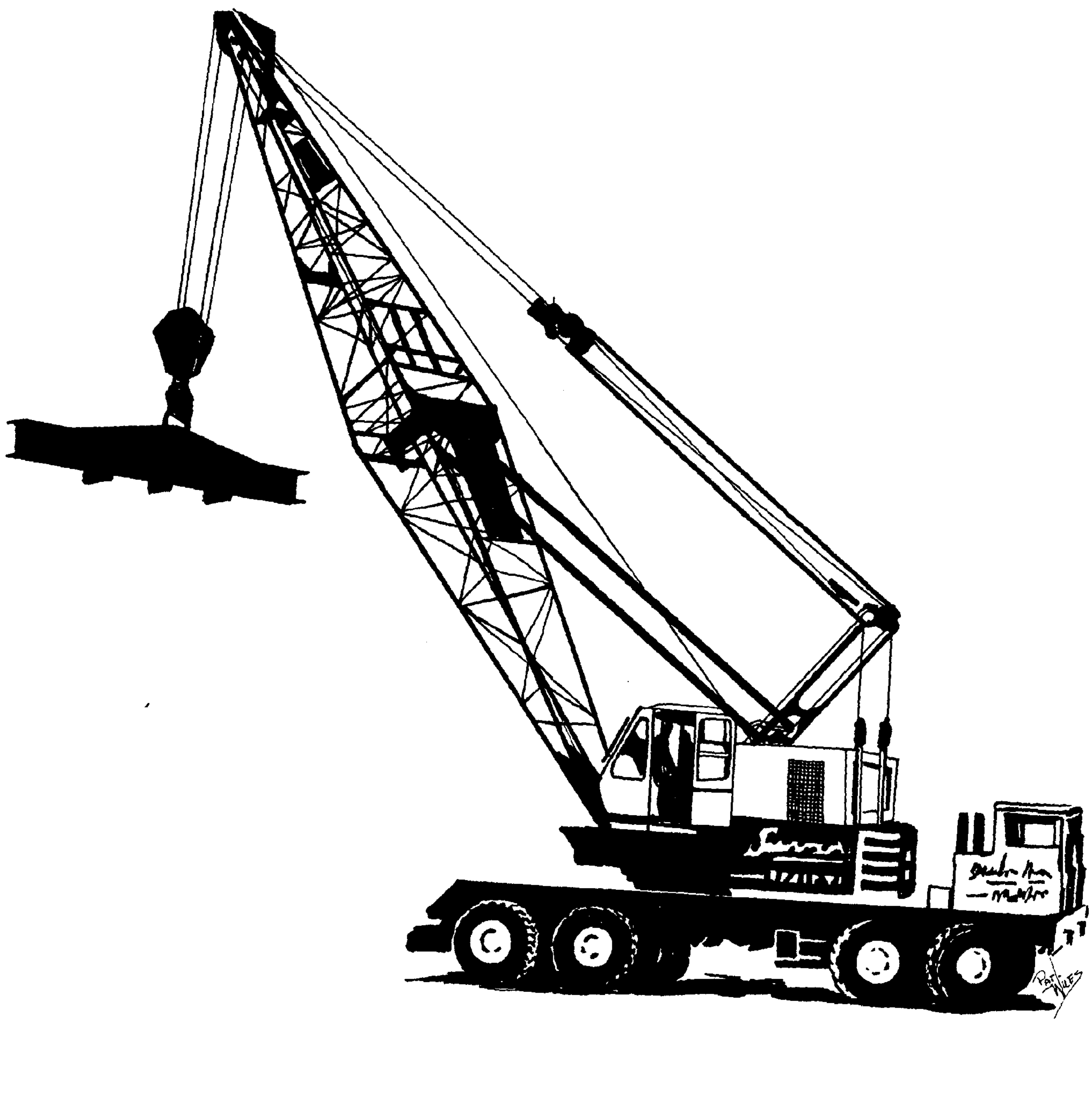
A specialized groundwater model (GWSIM) has been developed for use in Texas by the Water Development Board. The Board has applied a finite-difference model to simulate the hydraulic behavior of confined and unconfined aquifers. The model, originally developed by the U.S. Geological Survey (Pinder and Bredehoft, 1968), has been extensively modified by the Board.

The finite difference model has the capability of simulating water table elevations or piezometric levels under varying recharge and pumping patterns. In order to simulate the hydraulic behavior of a groundwater basin with this model, the basin must be represented by a grid of square or rectangular elements. Once the basin elements have been selected, the computer program calculates the water table elevation (or Piezometric head) in each element and all flows between for each time period simulated. Normal practice indicates that computational intervals of one year or less and total simulation periods of five to ten years are satisfactory to verify the accuracy of the model. The computer program requires three basic types of input data including: geometric data; aquifer characteristics; and hydrologic data with regard to initial groundwater levels, withdrawals, and recharge rates.

Verification of the groundwater simulation model involves assembling historical information on pumpage, recharge, springflows, and water surface elevations and using these data to simulate the historical water level changes in the aquifer. Aquifer water levels are used as the indicator of simulation verification and when all nodes of the model are within the user-selected error criterion, the model is considered to be verified. This is often a long and laborious procedure and involves continued-adjustment by simulated and historical aquifer water levels.

# APPENDIX H

## AN INVENTORY OF EXISTING OCS RELATED OIL AND GAS FACILITIES IN TEXAS



## AN INVENTORY OF EXISTING OCS RELATED OIL AND GAS FACILITIES IN TEXAS

### Petroleum Refineries and Petrochemical Complexes

The Texas coastal area contains the largest concentration of petroleum refineries and petrochemical complexes of any state in the nation. Approximately 40% of the nation's petrochemical industries and 26% of the refining capacity are located in coastal counties. In 1972, the total value of output from petroleum refineries along the coast amounted to $6.3 billion; the output value was $4.6 billion for petrochemical plants. At the same time, the refineries employed nearly 32,000 workers, and the petrochemical complexes employed approximately 45,000.

Figure H1

$ Million Output and Employment

| Area | Petro-chemical | Emp. | Petroleum Refineries | Emp. |
|---|---|---|---|---|
| Beaumont-Port Arthur Area | $ 908 | 9,433 | $ 2,476 | 14,997 |
| Houston-Galveston Area | 3,289 | 30,338 | 3,294 | 15,257 |
| Victoria Area | 184 | 1,953 | | |
| Corpus Christi Area | 202 | 2,708 | 522 | 1,371 |
| Lower Rio Grande Valley | 5 | 292 | | |
| Total | $4,588 | 44,724 | $ 6,292 | 31,625 |

Source: 1972 Census of Manufacturers, Department of Commerce, Washington, D.C. Texas Employment Commission, Austin, Texas, unpublished data.

If the total effect of these industries on the economy was measured, the impact would be significantly higher. For example, the total income effect of these industries amounts to $16.3 billion for refining and $12.3 billion for petrochemicals. These industries not only employ many workers and significantly contribute to the economy but they are also the most capital-intensive industries in the coastal area. They also use more water in their processing than any other manufacturing industries along the coast.

Figure H2

Petroleum Refineries

| Company | Location | Capacity |
|---|---|---|
| Jefferson County | | 1,294,000 |
| American Petrofina, Inc. | Port Arthur | 84,000 |
| Gulf Oil Co. | Port Arthur | 312,000 |
| Mobil Oil Corp. | Beaumont | 325,000 |
| Texaco | Port Arthur | 406,000 |
| Texaco | Port Neches | 47,000 |
| Union Oil of California | Nederland | 120,000 |
| Hardin County | | 18,100 |
| South Hampton Co. | Silsbee | 18,100 |
| Harris County | | 1,063,800 |
| Atlantic Richfield Co. | Houston | 213,000 |
| Charter International Oil | Houston | 64,000 |
| Crown Central Petro Corp. | Houston | 100,000 |
| Eddy Refining Co. | Houston | 2,800 |
| Exxon Co. | Baytown | 390,000 |
| Shell Oil Co. | Deer Park | 294,000 |
| Galveston County | | 473,500 |
| Amoco Oil Co. | Texas City | 333,000 |
| Marathon Oil Co. | Texas City | 64,000 |
| Texas City Refining Co. | Texas City | 76,500 |
| Brazoria County | | 85,000 |
| Phillips Petroleum Co. | Sweeny | 85,000 |
| Nueces County | | 474,100 |
| Champlin Petroleum Co. | Corpus Christi | 67,700 |
| Coastal States Petro Co. | Corpus Christi | 185,000 |
| Quintana-Howell Joint Venture | Corpus Christi | 44,400 |
| Southwestern Refining Co. | Corpus Christi | 120,000 |
| Suntide Refining Co. | Corpus Christi | 57,000 |
| Total Capacity | | 3,408,500 |

SOURCE: International Petroleum Encyclopedia (Tulsa, Ok: Petroleum Publishing Co., 1976).

Figure H3

Petrochemical Plants

| Company | Location | Feedstock | Major Products |
|---|---|---|---|
| Orange County | | | |
| Allied Chemical | Orange | Ethylene | Polyethylene |
| Firestone Synthetic Rubber & Latex Co. | Orange | Butane, Styrene Butadiene | SBR-BR, Butadiene |
| Gulf Oil Chemicals | Orange | Ethylene | Hd polyethylene |
| Phillips Petro | Orange | Heavy oil | Carbon Black |
| Jefferson County | | | |
| Arco Polymers, Inc. | Port Arthur | NA | Id polyethylene |
| Cosden Oil & Chemical Co. | Groves | Refinery products | Ethylene, propylene |
| Goodyear Tire & Rubber | Beaumont | Propylene, C-5 streams, butadiene | Polybutadiene |
| Gulf Oil Chemicals | Port Arthur | Refinery fractions | Ethylene, benzene, & benzene derivative |
| Houston Chemical Co. | Beaumont | Ethylene | Ethylene glycol, ethylene oxide |
| Jefferson Chem. Co. | Port Neches | Refinery gases | Ethylene, ethylene & propylene derivatives |
| Mobil Chemical | Beaumont | Petro fractions | Ethylene, propylene, benzene |
| Texaco | Port Arthur | Refinery fractions | Benzene, cyclohexane, toluene |
| Union Oil Co. of Calif. | Beaumont | Reformate | Toluene |
| Hardin County | | | |
| South Hampton Co. | Silsbee | NA | Benzene |

Figure H3 cont'd

| Company | Location | Feedstock | Major Products |
|---|---|---|---|
| Harris County | | | |
| Arco Chemical Co. | Channelview | Butanes, Butylenes | Butadiene, butylenes |
| Arco Chemical Co. | Houston | Refinery streams | Benzene, paraxylene |
| Arco/Polymers, Inc. | Houston | NA | Ethylene |
| Celanese Chemical | Clear Lake | Ethylene | Methanol |
| Charter Int'l Oil | Houston | NA | Solvents, toluene |
| Crown Central Petro Corp. | Houston | Reformate, toluene | Benzene |
| Diamond Shamrock | Deer Park - Pasadena | Ethylene, vinyl chloride, methane | Acetylene, ethylene dichloride, polyvinyl chloride |
| Diamond Shamrock | Pasadena | NA | Polypropylene |
| Dixie Chemical | Bayport | NA | Ethylene glycol |
| Ethyl Corp. | Pasadena | Ethylene | Alphaolefins, ethyl chloride, ethylene dichloride |
| Exxon | Baytown | NA | Benzene, ethylene, propylene, & derivatives |
| Goodyear Tire & Rubber | Houston | Butadiene-Styrene | Styrene-butadiene rubber |
| Gulf Oil Chemicals | Cedar Bayou | Ethane | Ethylene, Id polyethylene |
| Hercules, Inc. | Bayport | NA | Polypropylene |
| J.M. Huber Corp. | Baytown | Refinery bottoms | Carbon Black |
| Merichem Co. | Houston | Refinery treating wastes | Phenol |
| Oxirane Chemical Co. | Bayport | Propylene | Propylene oxide |
| Petro-Tex Chem. Corp. | Houston | Petroleum base stock | Butadiene |
| Phillips Petro. Corp. | Pasadena | Ethylene, propylene, natural gas | Ammonia, polyethylene |

Figure H3 cont'd

| Company | Location | Feedstock | Major Products |
|---|---|---|---|
| Reichhold Chemicals | Houston | Methanol | Formaldehyde |
| Rohm & Hass Co. | Deer Park | Natural gas | Acrylic esters |
| Shell Chemical | Houston | Petro fractions | Ethylene, propylene, benzene, & derivatives |
| Soltex Polymer Corp. | Deer Park | Ethylene | Hd polyethylene |
| Tenneco Chemicals | Pasadena | Natural gas, vinyl chloride | Methanol, ammonia |
| US Industrial Chemicals Co. | Houston | Ethylene | Ethylene derivatives |
| Galveston County | | | |
| Amoco Chem. Corp. | Texas City | Ethylene, benzene, petro fractions, refinery gases | Styrene |
| Marathon Oil | Texas City | NA | Cumene, toluene |
| Monsanto Co. | Texas City | Light crude oils, natural gas | Ethylbenzene, styrene |
| Texas City Refining Co. | Texas City | Refinery streams | Propylene |
| Union Carbide Corp. | Texas City | Natural gas, refinery gases | Ethanol, isopropanol |
| Fort Bend County | | | |
| Dow Chemical | Oyster Creek | NA | Ethylene derivatives |
| Chambers County | | | |
| Union Texas Petro. | Winnie | Reformate, naptha | Benzene |
| Brazoria County | | | |
| Amoco Chemical Co. | Chocolate Bayou | Propylene, ethylene | Ethylene |
| Dow Badische Co. | Freeport | Propylene, acetylene, cyclohexane | Caprolactum |
| Dow Chemical Co. | Freeport | NA | Benzene & ethylene derivatives |

Figure H3 cont'd

| Company | Location | Feedstock | Major Products |
|---|---|---|---|
| Monsanto Co. | Alvin | Light crude oil | Ethylene |
| Phillips Petro Co. | Sweeney | Heavy oil, natural gas liquid, benzene | Ethylene |
| Matagorda County | | | |
| Celanese Chemical | Bay City | Ethylene, cyclohexane | Vinyl acetate |
| Calhoun County | | | |
| Union Carbide Corp. | Seadrift | Ethane, propane | Ethylbenzene, styrene |
| Nueces County | | | |
| Celanese Chemical | Bishop | Natural gas | Formaldehyde |
| Champlin Petro Co. | Corpus Christi | NA | Cyclohexane |
| Coastal States Petro-Chemical Co. | Corpus Christi | Crude Oil | Toluene, benzene |
| Suntide Refining Co. | Corpus Christi | Refinery streams | Paraxylene, cumene |
| Cameron County | | | |
| Union Carbide Corp. | Brownsville | Butane | Acetic Acid |

NA means not available

SOURCE: International Petroleum Encyclopedia (Tulsa, Ok: Petroleum Publishing Co., 1976).

While the petroleum refineries and petrochemical complexes are generally thought of in the same light, they are separate processes. The petroleum refining industries use crude oil as feedstock and produce gasoline and other fuels used for transportation, power generation, and heating purposes. The petrochemical industry uses natural gas, natural gas liquids, and byproducts from petroleum refining as a feedstock. Petrochemical plants manufacture a multiplicity of products including rubber, plastic, synthetic fibers, and organic chemicals.

The refining and petrochemical complex is concentrated along the upper Texas Coast in the Houston and Beaumont-Port Arthur areas. Figures H2 and H3 show the location and capacity of these plants. In total, refineries in the Houston-Galveston area have a capacity of 1.5 million barrels per day. The Beaumont-Port Arthur area refineries have a capacity 1.3 million barrels per day.

## Ports

The ports and harbors of Texas can be thought of as comprising three separate yet inter-related components: deep draft ports, shallow draft ports, and the Gulf Intracoastal Waterway (GIWW).

### I. Deep Draft Ports

There are eleven distinct deep draft ports or port systems scattered along the Texas Gulf Coast. These ports, for the most part, have depths of 36 to 40 feet. (see Figure H4). In 1974, these ports handled a total of 229,440,637 short tons; of that total, approximately 171,780,000 short tons - 74.9% of the total - was petroleum, natural gas, chemicals or chemical products, or petroleum fuels or lubricants. The eleven deep draft ports are:

1. Orange - port facilities include 447,000 barrels of storage for crude petroleum and refined products storage. The port is well-served by rail and highways, and there are 35 piers, wharves, and docks. Nearly 31% of the tonnage handled in 1974 was petroleum-related.

Figure H4

| PORT OR WATERWAY | DRAFT | TOTAL TONNAGE HANDLED (IN MILLIONS OF SHORT TONS) 1960 | 1970 | 1974 | SELECTED COMMODITIES HANDLED IN 1974 (IN MILLIONS OF SHORT TONS) A Crude Petro-leum and Natural Gas | B Chemicals And Chemical Products | C Petroleum Fuels And Lubri-cants | Total: A,B&C | Total: A,B&C (As a % of Total Tonnage Handled in 1974) | Number of Berths | Petroleum Storage Capacity (In 1000 BBLs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Orange | 24-33 | 1.02 | 1.62 | 1.33 | .05 | .30 | .06 | .41 | 30.8 | 35 | 447 |
| Beaumont | 36-38 | 27.11 | 30.48 | 33.50 | 12.88 | 2.37 | 12.09 | 27.34 | 81.6 | 9 | 40,000 |
| Port Arthur | 36-41 | 28.21 | 22.67 | 27.80 | 10.30 | .55 | 13.92 | 24.77 | 89.1 | 9 | 26,000 |
| Sabine Pass Harbor | 30-40 | .37 | .28 | .39 | .29 | .01 | .04 | .34 | 87.2 | 1 | 0 |
| Houston | 36-40 | 57.13 | 64.65 | 89.11 | 18.81 | 10.07 | 30.27 | 59.14 | 66.4 | 218 | 12,000 |
| Texas City | 36-40 | 15.40 | 17.10 | 20.15 | 6.27 | 6.43 | 7.36 | 20.06 | 99.6 | 30 | 11,000 |
| Galveston | 44 | 6.07 | 3.46 | 7.17 | .21 | .13 | .15 | .49 | 6.8 | 37 | 0 |
| Freeport | 32 | 3.65 | 5.28 | 8.90 | 3.07 | 4.34 | 1.18 | 8.59 | 96.5 | 3 | 2,050 |
| Corpus Christi | 38-45 | 24.84 | 25.23 | 32.84 | 8.32 | 2.64 | 12.90 | 23.86 | 72.7 | Approx. 43 | 25,000 |
| Harbor Island | 47 | | 5.32 | 5.41 | 4.92 | - | .49 | 5.41 | 100.0 | 5 | |
| Brownsville | 36-38 | .97 | 4.99 | 2.84 | .38 | .33 | .66 | 1.37 | 48.2 | 18 | 1,000 |
| Port Isabel | 12 | .44 | .39 | .18 | .13 | 0 | 0 | .13 | 72.2 | | |
| Anahuac | Approx. 6 | .11 | .48 | .38 | - | .04 | - | .04 | 10.5 | | |
| Trinity River to Liberty | Approx. 6 | .97 | .36 | .36 | - | .04 | - | .04 | 11.1 | | |
| Cedar Bayou | Approx. 6 | .23 | .49 | .92 | .03 | - | .12 | .15 | 16.3 | | |
| Chocolate Bayou | 12 | - | 2.53 | 2.88 | 1.45 | .72 | .61 | 2.78 | 96.5 | | |
| San Bernard River to Sweeny | 9 | .84 | .53 | .51 | .06 | .04 | .30 | .40 | 78.4 | | |
| Matagorda Ship Channel | 12 | 2.04 | 4.48 | 4.93 | .17 | .55 | .08 | .80 | 16.2 | | |
| Channel to Victoria | 9 | .25 | 1.78 | 3.14 | - | 1.22 | .08 | 1.30 | 41.4 | | |
| Tributary Arroyo Colorado to Harlingen | 12 | .22 | .43 | .58 | .02 | .05 | .32 | .39 | 67.2 | | |
| Aransas Pass | 12 | .10 | 0 | .02 | - | 0 | - | 0 | 0 | | |
| Palacios | 12 | .14 | .10 | .07 | 0 | - | - | 0 | 0 | | |
| Port Bolivar | 12 | - | - | 0 | - | - | 0 | 0 | 0 | | |
| Clear Creek | Approx. 6 | - | - | .22 | - | - | - | - | - | | |
| Dickinson Bayou | Approx. 6 | - | - | .12 | - | - | - | - | - | | |
| Double Bayou | Approx. 6 | .06 | - | .03 | - | 0 | - | 0 | 0 | | |
| Port Mansfield | 8-16 | .11 | .02 | .04 | - | - | .01 | .01 | 25 | | |
| Rockport | 9 | 0 | 0 | 0 | - | - | - | - | - | | |
| TOTAL | | 170.28 | 192.67 | 243.82 | 67.36 | 29.83 | 80.64 | 177.83 | 72.9 | | |
| Gulf Intracoastal Waterway | 12 | 51.7 (1965) | 65.3 | 66.1 | 14.24 | 14.44 | 22.0 | 50.68 | 76.7 | | |

Sources: Waterborne Commerce of the U.S., U.S. Army Corps of Engineers
Final Environmental Statement: Maintenance Dredging: GIWW, U.S. Army Corps of Engineers, 1975.
Analysis of the Role of the GIWW in Texas, TAMU, 1975.
Primary Economic Impact of the GIWW in Texas, TAMU, 1974.

Note: 0 indicates less than .01 million

2. Port Arthur - approximately 26,000,000 barrels of storage for crude oil and refined products is available. There is a 1200-foot wharf structure with nine docks and access to land transportation is good. Over 89% of the tonnage handled in 1974 was petroleum-related.

3. Sabine Pass Harbor - located directly on open gulf waters, it is not an extremely active port. Nearly 90% of its 1974 tonnage, however, was petroleum related. There is one dock and no petroleum storage capacity.

4. Beaumont - the port is served by several rail companies and highways and has a capacity for storage of crude oil and refined products of nearly 40 million barrels. In 1974, almost 82% of the total tonnage handled was petroleum related. There are nine docks.

5. Galveston - the port has applied for an authorized depth of 67 feet. It is equipped with 22,639 linear feet of wharves and can dock 37 ships simultaneously. Approximately 7% of the tonnage handled in 1974 was petroleum-related. The port is well served by rail and highway systems. It has virtually no petroleum storage capacity.

6. Texas City - port facilities include storage capacity for over 11 million barrels of crude oil and refined products. Over 99% of its 1974 tonnage was petroleum-related. There are 30 docks.

7. Houston - Texas' largest port system and the third busiest in the nation has 218 wharves, piers, and docks in the vicinity. In 1974, over 66% of the total tonnage handled was petroleum-related. Over 12 million barrels of storage for crude oil and petroleum products is available.

8. Freeport - the port is well served by inland transportation systems and has storage space for about 700,000 barrels of crude petroleum and 1,350,000 barrels of finished products. Over 96.5% of the tonnage handled in 1974 was petroleum related. There are three docks.

9. Harbor Island - the port is located on an island in Corpus Christi Bay, has five docks, and is served by one highway in addition to the Gulf Intracoastal Waterway. It has applied for an authorized depth of 72 feet. A total of 100% of the tonnage handled in 1974 was petroleum-related.

10. Corpus Christi - port facilities include storage space for over 25 million barrels of crude oil or refined petroleum products,

nearly 7,000 linear feet of wharf frontage, and approximately 43 docks. Almost 73% of the total tonnage handled in 1974 was petroleum-related.

11. Brownsville - port facilities include five liquid storage terminal operators, 18 cargo docks (5 of which are oil docks), and over 6,000 feet of wharf frontage. Over 48% of its 1974 tonnage was petroleum related.

## II. Shallow Draft Ports

There are many small, shallow draft ports along the Texas Gulf Coast, but the most significant (See Map H1) are the channel to Liberty, Anahuac, Double Bayou, Port Bolivar, Cedar Bayou, Clear Creek, Dickinson Bayou, Chocolate Bayou, the channel to Sweeny, Palacios, the channel to Victoria, the Matagorda Ship Channel, Rockport, Aransas Pass, Port Mansfield, the channel to Harlingen, and Port Isabel.

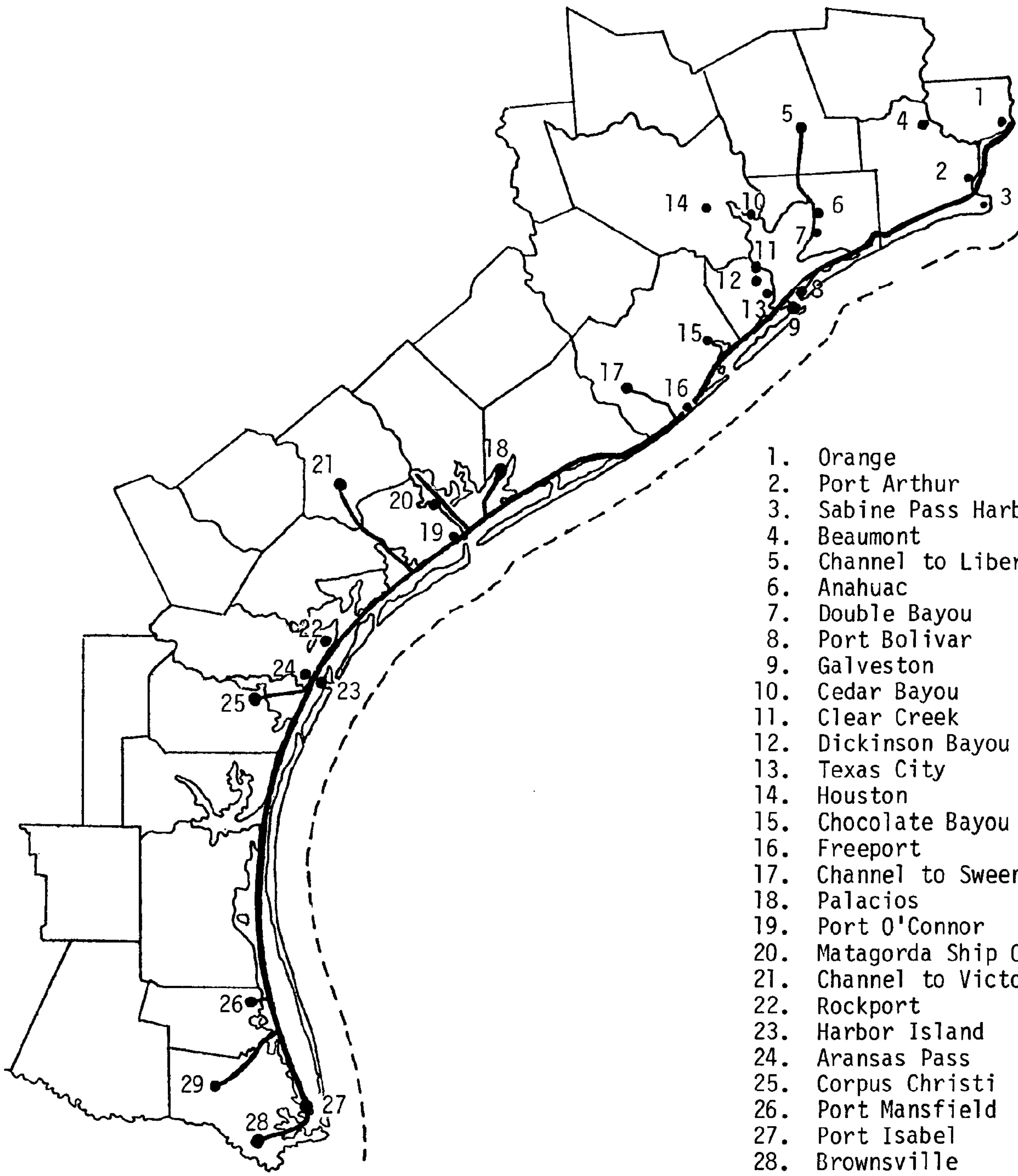
These ports combined handled a total of over 14 million short tons of cargo in 1974; slightly over 6 million tons of that total (42%) were petroleum-related. (See Figure H4.) The busiest of the shallow draft ports are Chocolate Bayou, the Matagorda Ship Channel, and the channel to Victoria.

## III. Gulf Intracoastal Waterway

The Gulf Intracoastal Waterway (GIWW) extends along the entire Gulf Coast from Brownsville, Texas to southern Florida. It serves as the primary lane for nearly all small commercial and recreational vessels berthed on the Gulf Coast. The Texas section of the GIWW extends along a 403 mile arc from the Sabine River at the Port Arthur Canal to the Port of Brownsville. (See Map H1.) The channel is generally 12 feet deep and 125 feet wide.

Tonnage handled on the GIWW has remained relatively constant in recent years. In 1968, 63.3 million short tons were handled; that figure fluctuated somewhat until a high of 68.9 million short tons was reached in 1972. The 1973 figure was 63 million. In 1971, 30.4% of the cargo handled on the Texas intracoastal waterway was petroleum products, 29.8% was crude petroleum, and 17.4% was chemicals.

Map H1



1. Orange
2. Port Arthur
3. Sabine Pass Harbor
4. Beaumont
5. Channel to Liberty
6. Anahuac
7. Double Bayou
8. Port Bolivar
9. Galveston
10. Cedar Bayou
11. Clear Creek
12. Dickinson Bayou
13. Texas City
14. Houston
15. Chocolate Bayou
16. Freeport
17. Channel to Sweeny
18. Palacios
19. Port O'Connor
20. Matagorda Ship Channel
21. Channel to Victoria
22. Rockport
23. Harbor Island
24. Aransas Pass
25. Corpus Christi
26. Port Mansfield
27. Port Isabel
28. Brownsville
29. Channel to Harlingen

(To avoid the possibility of double-counting tonnage handled, the GIWW is entered separately on Figure H4 and is not included in the "Total" row.)

In addition to existing ports and port systems, three port proposals merit attention. The Port of Galveston has applied for a permit to dredge the port and a 35-mile channel to the Gulf of Mexico to a depth of 67 feet. If the application is approved, the facility is projected to be in operation by 1981. It is estimated that the port could import 125 million tons of crude oil by the early 1990's.

Similarly, the Port of Corpus Christi has applied for a permit to deepen the Harbor Island facility at Port Aransas to 72 feet.

Finally, a consortium of nine oil and chemical companies have planned and designed an offshore, deepwater oil terminal 25 miles off Freeport, Texas, in the Gulf of Mexico. The facility, which could be completed by 1980, will include four monobuoys and a four-acre platform. Two 52-inch diameter pipelines would carry up to 2 million barrels of crude oil per day to storage facilities 31 miles away. Two additional monobuoys, a second platform and a third pipeline are projected for a later date.

## Offshore Drilling Rigs

In Texas, there are numerous offshore drilling contractors; most are located in Houston. However, the largest offshore drilling contractor in the world, Ocean Drilling Exploration Co. (ODECO) is headquartered in Dallas. A Texas base does not necessarily imply that the contractor is operating offshore Texas. In most cases, Texas-based contractors are world-wide operators. The data listed below show that in 1975 the number of rigs owned by Texas-based contractors were:

| | |
|---|---|
| Semi-submersibles | 25 |
| Jackups | 78 |
| Drillships | 29 |
| Fixed platforms | 68 |

Also, during 1975, Texas-based contractors had 39 rigs under construction devided into three groups:

| | |
|---|---|
| Semi-submersibles | 9 |
| Jackups | 20 |
| Drillships | 10 |

At the present time, there is a worldwide surplus of offshore drilling rigs. One reason for the surplus is because offshore activity has not expanded as rapidly as expected. Another reason is, because of escalating construction costs, older rigs can operate at a cheaper day rate than new rigs. In the past few years, there has been three identifiable levels of construction costs for offshore units - those units built before 1970, those built from 1970 - 74, and those delivered after 1974. In most cases the rig owner who bought the rig before 1970 will be the most competitive and least hurt in an oversupply situation. Those rig owners who bought after 1974 will be the ones most likely to be stacking their rigs or working them at prices that are less than profitable. Figure H5 shows the average cost of building offshore units for the three time periods.

Figure H5

Construction Cost - Offshore Units

$ Million

| | Jackups | Semi-Submersibles | Drillships |
|---|---|---|---|
| Prior to 1971 | 5.1 | 9.0 | 5.4 |
| 1971-74 | 10.3 | 22.8 | 13.1 |
| After 1974 | 19.2 | 33.9 | 45.4 |

SOURCE: Offshore Rig Data Services, "Offshore Rig Newsletter", October 1975. P.O. Box 19247, Houston, Texas 77024.

In Texas, there are five yards that build offshore drilling rigs. The two largest are Levingston and Marathon-Le Tourneau. In each yard there is currently some activity although they are not operating at full capacity.

| Name | Location |
|---|---|
| Baker Marine | Ingleside |
| Bethlehem Steel | Beaumont |

| | |
|---|---|
| Levingston Shipbuilding | Orange |
| Marathon-LeTourneau | Brownsville |
| Todd Shipyards | Galveston |

## Support Services

The process of drilling and completing an offshore well involves not only a drilling contractor and an oil company, but includes many different support services and suppliers of materials and equipment. These support services and suppliers may generally be classified into five groups: (1) those which transport the rig to the well site and assist in making the rig ready for drilling; (2) those which provide services and supplies for the drilling process; (3) those which provide services and supplies in completing the well; (4) those involved in pipeline construction; and (5) those involved in production platform construction and operation.

Some support services may be classified in more than one of the five groups. For example, marine transportation services are required for all phases of a drilling operation. They assist in transportation and setting up the rig, they provide supplies for the drilling operation and in completing the well, they assist in pipeline construction and they are necessary in production platform construction and operation. Others such as cementing services are only required in one phase of operating, that of completing the well. Figure H6 is a list of some of the support services required for each of the five phases.

All of the support groups have a common characteristic in that they are dependent on marine or air transportation in providing their service. In Texas, most of the offshore support groups are located in and around the Houston area. The reason for this is mainly logistical in that most of the offshore activity in Texas has been near the Houston area, and the Port of Houston and other nearby ports provide adequate docking and storage facilities for these activities. Figure H7 is a list of support services and some of their locations in the Texas Coastal area.

## Gas Plants

There are 79 gas plants located in the Texas Coastal Counties listed in Figure H8. The total capacity of those plants is 10,541.8 MMCF/D. That capacity represents 14.5% of the nation's total gas plant capacity and 36.3% of the State's. The State's total capacity, in turn, is 39.9% of the nation's.

Figure H6

Support Services and Supplies

1. Moving the Rig

| | |
|---|---|
| Tug Boats | Helicopters |
| Supply Boats | Service Boats |
| Fabricators | |

2. Drilling

| | |
|---|---|
| Supply Boats | Tool Rental |
| Crew Boats | Well Logging |
| Helicopters | Drill Pipe Suppliers |
| Catering Services | Drill Bit Suppliers |
| Mud Supply | Welders |
| Divers | Oil Well Supplies |

3. Completion

| | |
|---|---|
| Supply Boats | Cementing Services |
| Crew Boats | Tool Rental |
| Helicopters | Welders |
| Catering Services | Perforating Services |
| Cement Supply | |

4. Pipelines

| | |
|---|---|
| Pipe Suppliers | Pipe Burying Services |
| Pipe Laying Barges | Supply Boats |
| Helicopters | Pipe Coating |
| Welders | |

5. Production

| | |
|---|---|
| Helicopters | Fabricators |
| Crew Boats | Welders |
| Supply Boats | Catering Services |

Figure H7

Support Industry Locations

1. Tug Boats

   Freeport
   Houston
   Aransas Pass
   Galveston

2. Supply Boats

   Houston
   Freeport
   Aransas Pass
   Galveston
   Brownsville

3. Fabricators

   Corpus Christi
   Houston
   Beaumont
   Porter
   Brownsville
   Galveston

4. Helicopters

   Houston
   Sabine Pass
   Corpus Christi
   Freeport
   Rockport
   Galveston
   Pt. O'Connor
   Pt. Isabel
   Harlingen

5. Crew Boats

   Freeport
   Houston
   Aransas Pass
   Galveston
   Brownsville

6. Mud Supply

   Houston
   Corpus Christi
   Sabine Pass
   Freeport
   Rockport
   Galveston
   Pt. O'Connor
   Beaumont
   Brownsville
   Bay City
   Pt. Lavaca
   Ingleside
   Victoria
   Edinburg
   McAllen
   Robstown

7. Divers

Houston
Corpus Christi
Freeport
Galveston
Beaumont
Pt. Isabel
Orange

8. Tool Rental

Houston
Pasadena
Beaumont
Corpus Christi
Edinburg
Rockport

9. Well Logging

Houston
Corpus Christi
Sabine Pass
Freeport
Galveston
Pt. O'Connor
Beaumont
Bay City
Victoria
McAllen
Pharr
Mission
Portland

10. Drill Pipe Suppliers

Houston
Corpus Christi
Refugio
Beaumont
Brownsville
Rockport

11. Drill Bit Suppliers

Corpus Christi
Houston
Refugio
Victoria
Pasadena
Brownsville

12. Welders

Corpus Christi
Beaumont
Houston
Edinburg
Brownsville
Rockport

13. Oil Well Equipment Supply

Beaumont
Houston
Corpus Christi
Refugio
Pasadena
Freeport
Pt. O'Connor
Pt. Lavaca
Brownsville
McAllen

14. Cement Supply and Services

| | |
|---|---|
| Houston | Mission |
| Corpus Christi | Edinburg |
| Freeport | Victoria |
| Galveston | McAllen |
| Beaumont | |

15. Perforating Services

| | |
|---|---|
| Corpus Christi | Bay City |
| Beaumont | Refugio |
| Houston | Mission |
| McAllen | Pharr |
| Victoria | |

16. Pipeline Suppliers

| | |
|---|---|
| Houston | Corpus Christi |
| Beaumont | |

17. Pipeline Laying Barges/Burying Services/Coating

| | |
|---|---|
| Houston | Corpus Christi |

Figure H8

Gas Plants in the Texas Coastal Region

| County | No. Plants | Total Capacity/MMCF/D |
|---|---|---|
| Orange | - | - |
| Liberty | 3 | 117.0 |
| Jefferson | 7 | 570.0 |
| Harris | 4 | 333.0 |
| Galveston | 4 | 219.5 |
| Chambers | 5 | 452.0 |
| Brazoria | 6 | 2,039.0 |
| Matagorda | 7 | 1,002.0 |
| Jackson | 1 | 111.0 |
| Victoria | 3 | 154.0 |
| Calhoun | 4 | 231.5 |
| Aransas | 1 | 75.0 |
| Refugio | 4 | 207.5 |
| San Patricio | 7 | 443.8 |
| Nueces | 8 | 875.0 |
| Kleberg | 2 | 2,692.0 |
| Kenedy | 1 | 255.0 |
| Willacy | 1 | 64.0 |
| Cameron | - | - |
| Hidalgo | 6 | 459.5 |
| Hardin | 2 | 105.0 |
| Fort Bend | 3 | 136.0 |
| TOTAL | 79 | 10,541.8 |

# APPENDIX I

## ANTHROPOLOGICAL METHODS AND PERSPECTIVES FOR DEVELOPING COMMUNITY PROFILES

## ANTHROPOLOGICAL PERSPECTIVES AND METHODS FOR DEVELOPING COMMUNITY PROFILES

Although called by a different name, anthropologists have long been involved in developing of community profiles. Their ethnographies have described and analyzed the social, cultural, economic, and ecological systems of communities throughout the world. Although most of their work has been focused on small-scale social systems located outside of the United States, their methods and perspectives are easily adapted to the study of communities in complex societies.

The anthropological approach is holistic in nature and involves the study of formal and informal structures and networks. While every individual researcher has certain biases, the training of anthropologists stresses the need to view situations through the eyes of those who are being studied. The attitudes and perspectives of individuals who compose the cultural and social systems under study are the basic data of the anthropologist. Thus, the anthropological approach tends to qualitative as opposed to quantitative.

In order to gather this qualitative information, the anthropologist must participate in and observe a community. By interacting with the residents of a community and observing their behavior and life styles, the anthropologist is able to draw a portrait of their social and cultural system. Anthropologists argue that this interactive approach produces more complete and accurate information than a strict questionnaire or quantitative approach. However, questionnaires, in conjunction with on-site research can provide insights into a community's attitudes.

Unfortunately, the time frame of this study did not allow for the use of questionnaires, but certain other secondary information sources were utilized. These include: historical documents, 1970 census data, Calhoun County land records, Calhoun County building permit records, Calhoun County Independent School District records, Calhoun County voting records, and the records of the Texas Department of Public Welfare, the Texas Department of Mental Health and Mental Retardation, and the Texas Department of Health Resources. The Texas Department of Community Affairs was contacted, but had no information available on Port O'Connor due to its small size and unincorporated status.

Although these secondary information sources were helpful, the major body of data was collected through interviews and observation of the community. Upon arrival in the community, the primary researcher spent a number of days meeting individuals, talking with them briefly, and driving around the community. When questioned as to the reason for this visit, the primary researcher explained the nature and purpose of the study. Residents responded well. A number were very helpful in listing individuals who should be interviewed and even arranging an introduction to these persons. Fortunately, it was possible to conduct interviews with shrimpers, merchants, a few OCS personnel and with natives, residents, and newcomers. The primary researcher ate in a number of homes and frequented the local restaurants and stores. One afternoon was spent taking a boat ride with three shrimpers, two of whom were females, and one evening's activity included participating in the weekly volleyball game at the school. In short, the researcher was able to observe a wide variety of the daily activity in the community. Certain basic questions were asked in all in-depth interviews, but a variety of topics were usually covered. Four interviews were taped and notes were taken during others. Field notes were recorded at least daily. Only one individual was hesitant to talk with the researcher.

Informal discussions with various individuals occurred daily and these allowed the interviewer to check her perceptions and conclusions. Of course, in any field situation certain individuals appear to the researcher to be more knowledgeable and reliable. However, all individuals' perceptions must be carefully weighed and analyzed in order to produce an accurate portrait of a community. Every interaction and interview can be an enlightening experience, and this inductive research approach demands they all be considered.

After the on-site research was concluded, tapes were transcribed and notes reviewed. A card file with the collected information was divided into categories, such as social problems, attitudes toward growth, housing, etc. The writing of the final report involved extensive use of this file as well as field notes. These are the raw data of an ethnographic report.

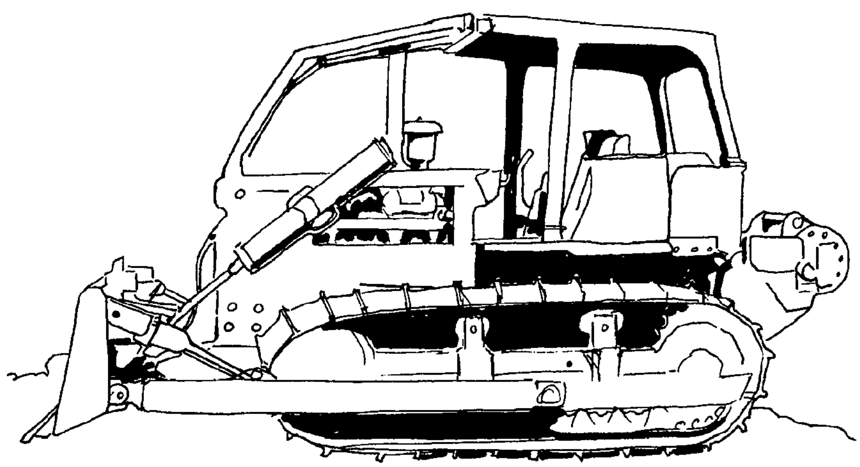
While the small size of the community allowed a rather short time period to be sufficient in establishing a baseline, it limited the study in certain ways. For instance, it was not possible to track down and interview recent out-migrants or part-time residents. It was also impossible to observe the community during the summer months. (One sunny weekend did give some idea of the change in the community due to influx of tourists, however.) The research was conducted during the bay shrimping off-season, and although this made it easier to talk with bay shrimpers, it was impossible to actually observe this activity.

The major focus of this study was on the residents' attitudes toward growth and change in their community. While it is not possible to isolate these attitudes from others, there were certainly many subjects which were not discussed at length. (For instance, the religious attitudes of residents.) In short, there were many aspects of the residents' lives that were not observed or discussed because of the short time allowed for this study. To produce a complete ethnography of this community would require at least a year rather than three weeks.

One final note on the research conducted in Port O'Connor. The OCS study involved persons from a variety of disciplines, and discussions with them were most helpful in the analysis of collected data. This team included an economist, a geologist, and two policy analyst one of whom is also a lawyer. Two sociologists also visited Port O'Connor for two days each and conducted informal interviews with residents; their observations were valuable additions to those of the primary researcher. All individuals mentioned above and another sociologist and two anthropoligists read a draft of the report and submitted comments and suggestions. However, while the primary researcher is indebted to all of these individuals for their helpful insights, they are not responsible for the specific contents of this study.

# APPENDIX J

# BIBLIOGRAPHY



# BIBLIOGRAPHY

## Introduction

The following Bibliography is divided into two groups; each of them is further broken into two sections. Entries are alphabetized within each of the four sections.

GROUP I contains entries for impact studies - environmental, economic, demographic, social, or infrastructural - including those related specifically to Texas and those not directly related to OCS oil and gas development. GROUP I contains a section of annotated entries for documents which are considered highly significant. The non-annotated entries, the second section of GROUP I, are works which are similar in content to those in the annotated section but which are not as widely available or are to some extent duplicative of those detailed in the annotated section. This non-annotated section also includes documents associated with OCS reserve estimates and other general Gulf of Mexico studies.

Both sections of GROUP I include documents which contain information associated with modeling techniques which are pertinent to evaluating OCS impacts. Because modeling is an area of research worthy of individual attention, a separate appendix dealing with modeling techniques was prepared. (See Appendix G.)

GROUP II of the Bibliography contains entries for documents which are considered to be inventories or descriptions of baseline data on the environmental, economic, demographic, social, or infrastructural characteristics of the Texas Gulf Coast. GROUP II is divided into two sections: (1) Natural Resources; and (2) Social, Economic, Demographic, and Intrastructural.

This Bibliography serves two purposes. First, it provides a list of invaluable documents for other OCS development impact-related research efforts. Secondly, it serves as a bibliography of materials gathered and consulted by RPC, Inc. during its study.

## GROUP I: ANNOTATED


Arthur D. Little, Inc. Petroleum Development in New England. 4 vols. Boston: New England Regional Commission, November, 1975.

This report analyzes the economic and environmental impacts on New England by petroleum industry development, including development of the OCS off New England. Volume I, the Executive Summary, includes the study methodology and conclusions. Volume II analyzes the impacts of 23 individual modules (scenarios) including several which postulate development in the OCS on Georges Bank. Volume III is more specific in terms of economic and environmental impacts, and Volume IV is appendices.

Arthur D. Little, Inc. Potential Onshore Effects of Deepwater Oil Terminal-Related Industrial Development. 4 vols. Cambridge: Arthur D. Little, Inc., 1974.

This 5-part, 4-volume study is an assessment of the onshore effects of deepwater terminal development in each of five areas: Machias, Maine; Sandy Hook, New Jersey; Grand Isle, Louisiana; the Delaware Bay, New Jersey; and Freeport, Texas. For each area, an economic and environmental baseline profile was developed and growth in industrial, economic, and environmental patterns that could be the result of a terminal were assessed. Impacts on population, personal income, tax revenues, land use, water demand, water pollution, air pollution, and more are analyzed. Part V is a collection of appendices and includes the economic and environmental methodologies.

Baldwin, Pamela L. and Baldwin, Malcolm F. Onshore Planning for Offshore Oil: Lessons From Scotland. New York: Universe Books, 1975.

This book focuses on a description of the North Sea OCS oil and gas development experience and on the lessons which can be learned from that experience and applied to U.S. OCS frontier areas, particularly the Atlantic OCS and the Gulf of Alaska. Included are chapters concerning what to expect onshore when oil and gas are discovered offshore, onshore development, construction of offshore platforms, pipelines, refineries, and more. The book recommends early planning for onshore impacts, dispersal of federal funds to affected states and localities, and local and state environmental impact statements to augment such federal statements.

Battelle Columbus Laboratories. A Study of Selected Coastal Zone Ecosystems in the Gulf of Mexico in Relation to Gas Pipelining Activities: Final Report to Offshore Pipeline Commission. Columbus, Ohio: Battelle Columbus Laboratories, 1975.

The report provides terrestrial, aquatic, and marine field data specifically collected at 6 sites to assess the environmental aspects of gas pipelining activities. Appendices include extensive sample records and statistical results. It demonstrates the kinds of positive and negative changes that occur as a result of pipelining. Responses to pipelining were found to vary depending on location, type of activity, and season.

Battelle Columbus Laboratories. Environmental Aspects of Gas Pipeline Operations in the Louisiana Coastal Marshes: Report to Offshore Pipeline Commission. Columbus, Ohio: Battelle Columbus Laboratories, 1972.

Results of initial studies by Battelle, which provide an overview of the broad environmental issues confronting the gas pipeline industry.

California. Office of the Governor. Offshore Oil and Gas Development: Southern California. Sacramento: Governor's Office, Office of Planning and Research. August, 1976; December, 1976; and Draft Findings and Recommendations February, 1977.

A series of three preliminary reports drafted to help the state and local governments deal with lease sale No. 35 and with resumed activity in the Santa Barbara Channel. The first two volumes identify major issues, problems and opportunities affecting OCS development. Volume I contains an analysis of onshore and offshore facilities and resources, of institutional issues affecting OCS development, of the environmental impact of development, of the transportation problems and petroleum industry operations. Volume II is a revision of Vol. I with an economic impact analysis, production forecasts and development scenarios added. Volume III contains the findings and recommendations of the task forces including recommendations for legislative changes in the OCS Lands Acts that would increase state and local government participation and strengthen environmental safeguards. New lease sales and development are not recommended until changes are made.

Florida State University. Florida Coastal Policy Study: Impact of Offshore Oil Development. Tallahasee: Florida State University, 1976.

A survey of impacts of OCS development in other states, a review of offshore exploration in Florida, and an overview of facilities associated with OCS oil and gas development are included. The study assesses the socio-economic impacts of a hypothetical offshore discovery with a maximum production of 136,000 barrels of oil and 215 million cubic feet of gas per day. Facilities, employment and income are projected. The report also analyzes the impacts on local government revenue and expenditures and on the environment. Deepwater port policy issues and offshore reserves and fuel availability are also examined.

Goldsmith, Oliver Scott and Morehouse, Thomas A. Impact Problems and Intergovernmental Aids in Alaska: Part I. Juneau, Alaska: University of Alaska, Institute of Social and Economic Research, 1976.

The study comprises six sections: an overview of intergovernmental aids, relevant governmental structures in Alaska, public finance impacts of rapid development, criteria for distributing impact aid, alternative administrative arrangements, and conclusions. The report concludes that the key to effective impact aid allocation is technical assistance on the part of state governments.

Goodman, Joel M. Decisions for Delaware: Sea Grant Looks at OCS Development. Newark, Delaware: Marine Advisory Services, University of Delaware, 1975.

This report describes the Baltimore Canyon trough and its oil and gas potential, the steps in developing OCS mineral resources, the OCS experiences in the Gulf of Mexico and Pacific Ocean, and the economic and environmental impacts of developing the Baltimore Canyon trough. The report concluded that development of the Mid-Atlantic OCS would require 1000 acres of shoreline and nearshore upland, and would result in a population growth of 15,000. A population growth of 45,000 for indirect support facilities is also estimated. The study suggests that shoreside activity and thus impact could be spread out along the coast. The final conclusion was that public expenditures would increase faster than revenues, substantially increasing tax burdens on area residents.

Grigalunas, Thomas A. Offshore Petroleum and New England: A Study of the Regional Economic Consequences of Petroleum Offshore Oil and Gas Production. Kingston, R. I.: University of Rhode Island Press, 1975.

A study which examines the impacts on New England of hypothetical offshore oil and gas development and possible petroleum refining activity in the area. Two scenarios of oil and gas development on the Georges Bank were tested - a low production case and high production case. Both high and low oil and gas prices were hypothesized as were two petroleum refinery scenarios. For each hypothesized development, estimates of impact on income, employment and other socio-economic indicators were made.

Gulf South Research Institute. Offshore Revenue Sharing. Baton Rouge: Gulf South Research Institute, 1975.

Using the situation in Louisiana as its central focus, this study evaluates the impact of OCS activities on state and local governments in adjacent areas. It includes a description of the OCS and its energy potential, analyses of the environmental and economic impacts of OCS production, and a history of mineral leasing on federal and offshore areas. Of particular interest is a section on tax revenues vis-a-vis public service demand due to increased OCS development. The study concludes that in 1972 over $260 million in taxes were foregone in Louisiana because of a lack of taxing authority over OCS developments. The report supports the sharing of federal lease revenues with affected states.

Gulf University Research Consortium. The Offshore Ecology Investigation. Galveston, Texas: Gulf University Research Consortium, 1973.

The report is the product of an effort to determine the ecological impact of petroleum drilling and production in coastal Louisiana. The study was conducted in a 400-square mile area including, and southward from, Timbalier Bay, Louisiana. The study includes 24 scientific papers by investigators. Subjects included are effects on phytoplankton, effects on zooplankton, descriptions of surface and subsurface sediments and turbidity, and many others. This volume is to be accompanied by Handbook on Procedures and Methods Employed in the Offshore Ecology Investigation.

Kash, Don E., et al. Energy Under The Oceans. Norman, Oklahoma: University of Oklahoma Press, 1973.

This landmark work is a technology assessment of OCS oil and gas operations; that is, it is "an attempt to systematically identify, analyze, and evaluate the potential environmental, legal/political, and other social impacts of OCS oil and gas technology." The book is comprised of five parts: An Introduction to Technology Assessment, The Development of OCS Oil and Gas Resources, Policy Issues Raised By OCS Development, A Comparison and Recommendations, and Appendices which include environmental pollution, offshore reserves, leasing procedures, and more. The book's description and graphics of OCS production equipment are very complete.

Mackin, J.G. A Review of Significant Papers on Effects of Oil Spills and Oilfield Brine Discharges on Marine Biotic Communities. Research Foundation Project 737. College Station: Texas A&M University, 1973.

Article includes summary and discussion of facts concerning oil spills and brine discharges based upon an annotated bibliography of 836 references, international in origin. Includes case study review of 3 oil spills and analyses of oil spill effects upon different biotic groups: intertidal, planktonic, shore birds, etc. Also includes review of bacterial degradation of petroleum.

Mackin, J.G. A Study of the Effects of Oilfield Brine Effluents on Biotic Communities in Texas Estuaries. Research Foundation Project 735. College Station: Texas A&M University, 1971.

This report of research at six Texas bay and lagoon oil production sites may be outdated to the extent that brine effluents are now prohibited from being directly discharged into Texas coastal waters. The results are, however, relevant in their own right and to other regions without these restrictions. The analysis of impact is evaluated in terms of the distance from the point-source that affects are seen. Affects are measured by spatial changes in diversity, species abundance, ability to recolonize substrate, and by yearly change in species numbers as a measure of the affect on reproductive capability.

Mathematical Sciences Northwest, Inc. *A Social and Economic Impact Study of Oil Related Activities in the Gulf of Alaska.* Bellevue, Washington: Mathematical Sciences Northwest, Inc., 1975.

A study (done for the Gulf of Alaska Operators Committee) which estimates the economic and social impact of resource development in the Gulf of Alaska on the Alaskan communities of Juneau, Yakutat, Cordova, Whittier, Seward, and Kodiak. Using basic projections of 120,000 barrels of oil per day/per field and by varying those figures in alternative scenarios, indirect and direct employment, wages, population, and more were projected. Impacts on the fishing and canning industries are also included.

McAlister, John; Linvill, William; and Saunders, Harry, eds. *A Technological Assessment of the Impact on California's Coastal Zone from Proposed Offshore Oil and Gas Development.* Palo Alto: Stanford University Press, 1973.

A California impact study which includes a description of such background issues as national energy policy, preparedness for and consequences of OCS development, and the application of the Coastal Zone Management Act. It further analyzes California's projected energy consumption; its supplies; its harbor and port facilities; production and exploration equipment necessary for OCS development; energy transportation systems; the likelihood of major oil spills; and the impacts of natural gas and petrochemical facilities on the State of California. It concludes with legislative options regarding OCS development.

Mixon, J. *Environmental Analysis for Development Planning in Chambers County, Texas: A Proposed Incremental Change System for Texas.* Houston: Southwest Center for Urban Research, Technical Report, 1974.

Report includes service of regulations, legislation, and opinion concerning natural resources, principally land and water use. The review is used as a basis for designing a viable incremental change system developed with a scenario for developing the change program. The report includes specific proposals pursuant to the enactment of the system of growth.

Nelson-Smith, A. Oil Pollution and Marine Ecology. New York: Plenum Press, 1973.

This is an excellent compendium of data, references, and opinions evaluating the effects of oil pollution at sea. The history of petroleum industry, shipping, and pollution control at sea is summarized. Sources of oil pollution at offshore production, shipping, and harbor terminals are described. The chemical, physical, and behavioral properties of spilled oil on marine organisms, marine communities, and on marine-based economies (tourism and fishing) may be one of the most comprehensive treatments on the subject currently available. Institutional and technical approaches to dealing with spills are described and evaluated in terms of performance, problems, and limitations.

New England River Basins Commission. A Methodology for the Siting of Onshore Facilities Associated With OCS Development: Draft Interim Report #1. Resource and Land Investigation (RALI) Project: 1975, 1976 (corrected).

This study is designed to provide information which will be of immediate assistance to states involved in planning for the onshore effects of OCS oil and gas activities. The four distinct phases of OCS development are defined, but major emphasis is given only to exploration and development. The study includes requirements for maintenance of OCS development such as service bases, platform construction yards, refineries, housing, and others. Estimates of land space and labor requirements for specific projects are also provided. A hypothetical analysis of OCS activity in the Georges Bank area surveys the implications for high and low find scenarios and quantifies the impacts therein. Finally, an annotated summary of priorities lists valuable environmental and governmental considerations for OCS impacts.

New Hampshire. Department of Resources and Economic Development. The Impact of Offshore Oil - New Hampshire and the North Sea Experience. Concord, New Hampshire: New Hampshire Department of Resources and Economic Development, 1975.

The State of New Hampshire has only 18 miles of shoreline and no oil or gas wells but is in the forefront of encouraging development of the Atlantic OCS. This report analyzes the development of oil and gas production in the North Sea and its impact on Scotland. A "Background" chapter includes a discussion of North Sea and Atlantic OCS exploration and production. The report includes an overview of techniques and types of equipment used in the offshore oil industry. Includes recommendations concerning New England port development, heavy industry siting, refinery construction, oil terminals, and more.

Offshore Oil Task Group. The Georges Bank Petroleum Study. 3 vols. Cambridge: Offshore Oil Task Group, Ocean Engineering Dept., Massachusetts Institute of Technology, 1973.

A two volume study with executive summary reporting the expected impacts of hypothetical Georges Bank petroleum development. Volume I presents the model used to hypothesize petroleum production schedules and the impact of several petroleum development scenarios on the real regional income of New England. The "no offshore petroleum cases" and 64 possible combinations of growth rate, cost of capitol, refinery location, and distribution systems for offshore petroleum discoveries are analyzed. Volume II reports the analysis of environmental implications of economic development hypothesized in Volume I. The analysis is restricted to impacts on air and water quality. Models are presented and results described for estimating oil discharges and spill probability, trajectory, and of specific biological impacts of such water pollution, assuming no attempt is made to contain or remove spills. Two chapters describe containment and removal practices and costs, and background information on biological effects of spills, including the physical and chemical qualities of different crudes. Impacts on air quality are assessed for different sources of refinery emissions, and are contrasted for the "all-oil" or oil and gas offshore find cases.

Resources for the Future, Inc. Energy, Heavy Industry, and the Main Coast: Report of the Governor's Task Force. Washington, D.C.: Resources for the Future, Inc., 1972.

This document includes a background chapter on industrial development on the Maine coast, projects possible futures and policies, selects a preferred future, and makes policy recommendations. Among the recommendations are: (1) heavy industry in the Maine coastal zone should be confined to two zones and (2) oil development should be limited to the Portland area with the addition of another area at a later date. Appendix I includes an analysis of the benefits and costs associated with the location of heavy industry on the Maine coast, including effects on employment and income, impact on tax base and public revenues, environmental damages, and more.

Resource Planning Associates, Inc. Identification and Analysis of Mid-Atlantic Onshore OCS Impacts. Cambridge, Massachusetts: Resource Planning Associates, 1975.

This study is primarily a critical analysis and evaluation of six projects concerning OCS impacts. Although much of the book sorts what is good and bad about the six individual studies, it is through that comparison and sorting process that much can be learned about the methodologies, points of interest, and policy issues of other impact studies. For example, each of the analyses provides a particular projection concerning economic, social, land use, air quality, water quality, and fiscal impacts of OCS development. For each of the categories, the base cases are presented and the methodology assumptions and findings of the six reports, where applicable, are compared and analyzed.

Scott, John T. Profile Change When Industry Moves Into a Rural Area. Madison: University of Wisconsin Press, 1973.

This report describes the economic and social impact experienced by a rural area when industry is introduced. It includes a community profile of resources and products of the community and concludes that the primary impacts are on land use and support systems such as water and energy supply. Impacts on labor force, retail sales, housing, schools, and public services are also analyzed. Includes a case study of the construction of a manufacturing establishment in northern Illinois.

Smith, S. H. "Effects of Water Use Activities in Gulf of Mexico and South Atlantic Estuarine Areas." In "Symposium on Estuarine Fisheries," pp. 93-101. Edited by R. F. Smith. In Transactions of the American Fisheries Society. Vol. 95: American Fishery Society Special Publication No. 3, 1966.

The effects of navigation projects' alterations of upland water source, dredge and fill operations, and of hurricane protection projects are evaluated with case examples from the Gulf of Mexico and South Atlantic. The evaluation is conducted in the framework of need and interest in the projects, benefit-cost ratios, and coastal engineering factors such as tide, current, freshwater discharge, salinity intrusion, flushing of pollutants, and shoreline processes.

Texas A&M University. Analysis of the Role of the Gulf Intracoastal Waterway in Texas. College Station: Texas A&M University, 1974. (Sea Grant Doc. #TAMU-SG-75-202.)

Sections of this report describe environmental and economic characteristics of the Texas regions bordering the G.I.W.W. or being influenced by it. The value of this report lies in sections other than this inventory. The chapter "Engineering Aspects of Operation and Maintenance" includes for 17 sections of the Texas G.I.W.W., maintenance requirements and dredging costs. The economic impact on the State of Texas is summarized, alternatives to federal funding of maintenance, and legal aspects involved in continued operation and maintenance of the G.I.W.W. are contained in three other significant chapters.

Texas. Office of the Governor. Office of Information Services. An Economic Impact Analysis of the Proposed 1974 Outer Continental Shelf Oil and Gas General Lease Sale, Offshore Texas, by Herbert W. Grubb. Austin, Texas, 1974.

This report concludes that for each dollar of crude oil produced, the Texas economy effects are $2.41; and for each dollar of refinery output, the effect is $2.59. For each job in production, there are 6.8 jobs in the Texas economy; for each job in refining, there are 9.7 jobs elsewhere in Texas. In terms of OCS development, the impacts from lease payments, construction, and production were analyzed. The impact of the 1974 sale was estimated to range from $16.3 billion to $29.9 billion in additional economic activity in Texas.

Texas. Office of the Governor. Office of Information Services. Management Science Division. Benefits and Costs to State and Local Governments in Texas Resulting from Offshore Petroleum Leases on Federal Lands. Austin, Texas, 1974.

This study concludes that the impact on state and local revenue from offshore production is less than from onshore production, and that public service requirements cannot be financed using normal mechanisms because a portion of the tax base (offshore physical plant) is not available. The study estimates that the annual revenue to state and local governments in Texas will be $48.9 million, but that services costing $111 million per year will be required, resulting in a net cost of $62.1 million annually.

THK, Inc. Impact Analysis and Development Patterns Related to Oil Shale. Denver: THK, Inc., 1974.

This report assesses the impact of growth on the existing economic, social, and physical conditions of a three-county area in Colorado. Three scenarios are applied: (1) normal growth trends, (2) moderate oil shale development, and (3) intensive oil shale development. A discussion of land area and service requirements to meet the projected population increases is included. Public facilities needs and costs and population distribution in such areas as development patterns, transportation, land use planning, and housing.

U.S. Army Corps of Engineers. Crude Oil and Natural Gas Production in Navigable Waters Along the Texas Coast: Final Environmental Statement. Galveston: U.S. Corps of Engineers, 1972.

Following EPA guidelines for formating EIS's, this statement summarizes the environmental setting of the Texas Coastal Zone, especially pertaining to mineral resource development in the Texas OCS. The section on environmental impact gives review of probable and possible affects of permitting, production, including secondary activities of dredging and spoil placement operations, construction of drilling basins and access channels, as well as installation and operation of producing platforms. Impacts discussed are of spills, subsidence, navigation impairment, spoil disruption of marshland, and of dredging turbidity.

U.S. Army Corps of Engineers. Maintenance Dredging in the Corpus Christi Ship Channel: Final Environmental Statement. Galveston: U.S. Corps of Engineers, 1975.

Following EPA guidelines for EIS formats, the report summarizes the geology, climate, wildlife and natural resources, economies, and port facilities in the region of the Corpus Christi Bay system. The section on environmental impact includes evaluation of direct impact of dredge and disposal operations on vegetation, benthic organisms and water conditions. Results of a monitoring program to assess the affect of dredging and a review of other studies provides a good base for determining probable extent of impact of dredging operations in other areas.

U.S. Congress. House of Representatives. Ad Hoc Select Committee on Outer Continental Shelf. Effects of Offshore Oil and Natural Gas Development on the Coastal Zone. 94th Cong., 2nd Sess., 1976.

This comprehensive study includes oil and gas resource estimates, OCS development equipment descriptions, an analysis of leasing systems, offshore and onshore environmental impact, socioeconomic impact on the Coastal Zone, impacts on the fishing industry, and alternative means of compensating coastal states for OCS impacts. The report concludes that OCS operations are environmentally sound; that oil spills are not a major problem; that onshore impacts will be primarily local; and that local governments face expenditures in advance of projected, future tax revenues.

U.S. Congress. Office of Technology Assessment. Ocean Assessment Program. Coastal Effects of Offshore Energy Development: Oil and Gas Systems. 96th Cong., 2nd Sess., 1976. (Summary of interim report.)

This study analyzes the coastal effects of offshore oil and gas development and the consequences of such coastal effects for New Jersey and Delaware. The issues of a federal management system, state access to OCS information and decisions, fiscal effects on state and local governments, oil spill liability and compensation, management of technologies, and others are analyzed, and Congressional options are outlined.

U.S. Congress. Office of Technology Assessment. Coastal Effects of Onshore Energy Systems. Vol. I and Vol. II: Working Papers. Washington, D.C.: Government Printing Office, November, 1976.

A two-volume study which isolates the likely effects of OCS oil and gas development, deepwater ports, and floating nuclear plants on the coastal areas of New Jersey and Delaware. In terms of OCS oil and gas production, the study fully described the technology and equipment necessary for the operationalization of two distinct production level scenarios. The study concluded, in part, that OCS

production is not likely to damage the environment if properly managed and monitored and that mid-Atlantic State governments will probably realize a net fiscal benefit, although local deficits would occur. The study includes an extensive legal/institutional/regulatory analysis. Volume II contains ten working papers including analyses of biological impacts, fiscal effects, and oil spill risk. The project included a public participation element.

U.S. Congress. Senate. Committee on Commerce. *Development of Oil and Gas on the Continental Shelf*. 93rd. Cong., 2nd Sess., 1974.

A short but complete report which estimates continental shelf reserves, outlines legal and jurisdictional problems, isolates environmental issues, describes offshore facilities and offshore leasing procedures, and describes pending legislation associated with the continental shelf. A reverse chronology of OCS activities and lists of Congressional Reports and Hearings are included.

U.S. Congress. Senate. Committee on Commerce. *Energy Facility Siting in Coastal Areas*. 94th Cong., 1st Sess., 1975.

A comprehensive analysis of current OCS activities, constraints on and problems associated with energy facility siting in coastal areas, and effects of OCS development. The report includes an in-depth analysis of the Coastal Zone Management Act of 1972 and its proposed amendments. Appendices include energy siting programs in California, Montana, Maryland, and Minnesota; and a comparison of alternative methods for distributing coastal energy impact funds.

U.S. Congress. Senate. Committee on Commerce. *North Sea Oil and Gas: Impact of Development on the Coastal Zone*. 93rd Cong., 2nd Sess., 1974.

Drawing on the North Sea experience, this study drew several conclusions but did not recommend specific legislation. The economic impact and leasing system, effect on employment, socio-economic and marine environment problems, onshore planning, and a Shetland Island case study are included. The study isolated several implications for the United States: (1) the Federal government should prepare and inform state and local governments as to coastal facilities and services to be needed, (2) state and local governments should play significant roles in planning, and (3) broad national, state, or local interests should be taken into consideration in the planning process.

U.S. Congress. Senate. Committee on Commerce. *Outer Continental Shelf Oil and Gas Development and the Coastal Zone*. 93rd Cong., 2nd Sess., 1974.

An extensive discussion of OCS information needs; socio-economic and environment impacts of OCS development on the Coastal Zone; leasing, production, and transportation practices; and more. The report recommends that (1) legislation to improve OCS policies and practices should be enacted; (2) no leasing in frontier areas should occur until the Interior Department demonstrates that such leasing is necessary, safe, and in the public interest; and (3) OCS leasing programs should be replaced with more realistic lease targets.

U.S. Congress. Senate. Committee on Commerce. Outer Continental Shelf Oil and Gas Leasing Off Southern California: Analysis of Issues. 93rd Cong., 2nd Sess., 1974.

Includes a historical background of California offshore oil and gas development and procedures for leasing OCS lands. The study recommends that (a) current leasing schedules should be replaced with a lower level of leasing and frontier areas should be avoided, (b) leasing procedures should include participation by State, local, and regional officials, (c) the Federal government should be responsible for exploration, (d) impacts on the Coastal Zone should be carefully assessed, and (e) leasing programs should be justified to Congress.

U.S. Council on Environmental Quality. OCS Oil and Gas: An Environmental Assessment: Report to the President. 5 vols. Washington, D.C.: Council on Environmental Quality, 1974.

This assessment was prepared in response to President Nixon's April, 1973 request to study the environmental impact of oil and gas production on the Atlantic OCS and in the Gulf of Alaska. The 5 volume report documents the national and worldwide energy resources and reserves, technology for OCS development and environmental protection, institutional and legal mechanisms for managing OCS development, and the effect of unusual natural phenomena, such as earthquakes and hurricanes, on OCS operations. Hypothetical locations of production on the Atlantic OCS and in the Gulf of Alaska are the base for evaluating the impacts of OCS development in these areas on coastal economics, social infrastructure, land use, and pollution, and are also the base for evaluating the probability of oil spills and their magnitude of effect. The impact of high and low levels of development are extrapolated from an extensive 1971 baseline economic, social, and environmental inventory to the years 1985 and 2000.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration. Office of Sea Grants. The Impact of Offshore Oil Production on Santa Barbara County, California, by Susan M. Wilcox, and Walter J. Meade. Washington, D.C.: Department of Commerce, 1973.

This study attempts to identify and measure the impact of oil activity directly or indirectly on Santa Barbara County revenues and expenditures for the purpose of determining net gain or loss to the County due to offshore oil production. Wage income, taxes, government expenditures, other economic sectors (fishing, tourism, etc.), and environmental changes are analyzed. The study concluded that the net impact of offshore oil production on the Santa Barbara County budget is $1,679,795 in annual revenues.

U.S. Department of Interior. Bureau of Land Management. Final Environmental Statement: Outer Continental Shelf Oil and Gas General Lease Sales-Gulf of Mexico. New Orleans: U.S. Department of the Interior. (Texas OCS sales include numbers 34, 37, and 38; and draft environmental statements for sales numbers 41 and 44.)

Environmental impact statements prepared pursuant to EPA guidelines. Include description of proposal, reserves, environment, environmental impacts, mitigating measures, unavoidable impacts, commitment of resources, alternatives, consultation and coordination, 1:1,000,000 maps of the Texas coastal zone and OCS, and various attachments.

U.S. Department of Interior. Bureau of Land Management. The Outer Continental Shelf Oil and Gas Development Process: A Background Paper for State Planners and Managers. Washington, D.C.: BLM, 1976.

This paper provides an overview of the oil and gas development process on the OCS in terms of development phases which can be related to state coastal zone management efforts and other planning programs. Brief discussions of each phase of OCS development include approximate time frames; description of industry development activities and correlated governmental actions; and the type and rough magnitude, if available, of potential impacts that may be expected from the activities of each phase.

U.S. Department of Interior. Bureau of Land Management, and College of Marine Studies, University of Delaware. A Study of the Socio-Economic Factors Relating to the Outer Continental Shelf of the Mid-Atlantic Coast. 9 vols. Washington, D.C.: Bureau of Land Management, 1973.

This study was designed to provide BLM with sufficient data to describe the socio-economic impact of OCS development on the Middle Atlantic Region. The study includes a description of the area's industrial and commercial activities, including ports, manufacturing, tourism, and others; the area's petroleum industry; its demography; and its land and water use, pollution sources, and transportation systems. The report is not an assessment of impacts; it provides data with which such impacts can be assessed.

U.S. Department of Interior. Geological Survey. Movement and Effects of Spilled Oil Over the Outer Continental Shelf - Inadequacy of Existent Data for the Baltimore Canyon Trough Area, by H. J. Knebel. Circular 702. Washington, D.C., 1974.

An evaluation of the physical processes which determine the movement and extent of oil spills on the outer continental shelf. The paper includes a review of literature reporting on the Baltimore Canyon Trough Area, and also an outline of the deductive approach to the problem. It generally finds an inadequacy of data for suitable predictions, a finding which is projected to other outer continental shelf areas in which leasing is occurring.

Vlachos, Evan, et al. Social Impact Assessment: An Overview. Fort Belvoir, Virginia: U.S. Army Engineer Institute for Water Resources, 1975.

This report, authored by a consultant team made up of members from seven universities, presents an overview of the assumptions, methodologies, procedures for data collection, and techniques of conducting social impact assessment as part of an entire project assessment package. The report recommends greater allocation of resources to social impact assessment and the use of advisory boards of social scientists. Also included is an extensive bibliography of environmental social science reference works.

Washington, D.C. American Institute of Planners. David Stoloff and Judith Stoloff. "Social Impact Assessment: A Tool for Project Planning." Paper presented at the 58th Annual Conference, AIP, San Antonio, Texas, 1975.

This paper describes a method of social impact assessment developed as part of a study commissioned by the U.S. Corps of Engineers for two water resource development projects in Eastern Kentucky. The authors isolated five measures of quality of life: (1) Income, (2) Housing, (3) Isolation-integration and subjective sense of well-being, (4) Health, and (5) Outdoor recreational opportunities. Positive and negative impacts on relocatees and residents of area surrounding the project were analyzed, and recommendations for project modification were made.

Woodward-Clyde Consultants. Mid-Atlantic Regional Study: An Assessment of the Onshore Effects of Offshore Oil and Gas Development. Woodward-Clyde Consultants, 1975.

This report attempts to describe certain efforts which may result from OCS development and to provide a guide for informed decision-making. The study developed an OCS development scenario. The report concluded that: (a) development can proceed only if accompanied by some onshore construction, but the environmental

effects will be minor if suitable sites are selected; (b) OCS related employment will be modest, and the demands on services will be small compared to the demand created by growth unrelated to OCS development; and (c) the economic benefits accruing to the region may defray costs of providing services to an increased population.

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